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**WHEEL CREEK  
WATER CHEMISTRY MONITORING  
YEAR 3 REPORT**

Prepared for:

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## **1.0 INTRODUCTION**

Harford County has received a Chesapeake and Atlantic Coastal Bays 2010 Trust Fund grant to address impacts to Wheel Creek through stream restoration, stormwater BMP retrofits, public outreach, and physical, biological, and water chemistry monitoring. Additionally, through mutual agreement with Maryland Department of the Environment (MDE), Wheel Creek has been identified as the County's priority watershed to satisfy National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) monitoring requirements.

Wheel Creek watershed drains 435 acres consisting of high density residential and commercial land uses in the headwaters, and medium and low density residential and forest land uses in the remainder. The stream has been altered by changes in hydrology in the watershed associated with recent urbanization and historical agricultural land use. Imperviousness has increased to 27% in the past three decades of development (Harford County DPW 2008).

Harford County contracted with Versar, Inc. to conduct stormwater runoff monitoring in Wheel Creek to comply, in part, with both the monitoring requirement of the MS4 permit and the monitoring requirements associated with the Chesapeake and Atlantic Coastal Bays 2010 Trust Fund stream restoration initiative. Baseflow monitoring and nutrient synoptic water chemistry sampling were completed by Harford County Department of Public Works (DPW). Long-term flow monitoring, coincident with this monitoring effort at all three of the water chemistry monitoring stations, was completed by Maryland Department of Natural Resources (DNR). DNR also completed a round of pre-restoration biological and physical monitoring each spring and summer since 2009 (Becker 2010). A baseline geomorphological assessment was carried out by the County during January 2010 (KCI Technologies 2010). USGS operates a stream flow gauging station near the mouth of Wheel Creek (USGS Station 0158175320) and a stage level gauging station and tipping bucket rain gauge in Atkisson Reservoir (USGS Station 01581753).

This report documents the water chemistry monitoring activities undertaken by Harford County, Versar and Maryland Department of Natural Resources, and summarizes the data obtained during calendar year 2013. The activities included ten storm events, monthly baseflow monitoring, and nutrient synoptic sampling in the Wheel Creek watershed.

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## **2.0 STUDY AREA AND STUDY DESIGN**

Wheel Creek forms a portion of the Atkisson Reservoir Watershed and resides within the Bush River Basin. It consists of approximately 435 acres of watershed, 2.2 linear stream miles, and stormwater management facilities. Four stream reaches are targeted for restoration and five stormwater facility retrofits are planned in the drainage area (Harford County DPW 2008). Restoration and retrofit activities began in 2011. Pre-construction data will be used to assess performance of a portion of the stream restoration and stormwater BMP retrofit projects. Construction on Pond A at Gardens of Bel Air began on September 8, 2012 and was completed December 20, 2012. Instream restoration on Calvert's walk, located in Wheel Creek's upper reaches above Pond A, started on January 14, 2013 and was completed approximately April 5, 2013.

The water chemistry monitoring effort study design employs comparisons of pre- and post-restoration and retrofit conditions. Three long-term automated water chemistry sampling and flow logging were established at stations WC002, WC003, and WC004 (Figure 2-1). Station WC004 is situated on a tributary immediately downstream of a planned stormwater retrofit at Festival Shopping Center (Point C). Stations WC003 and WC004 bracket planned stormwater control retrofits at Pond D and Pond E along Wheel Creek Tributary. Station WC002 is located on the mainstem and water chemistry data collected there will provide an overall assessment of the benefits of retrofit and restoration projects in upstream tributaries (Figure 2-2). Baseflow monitoring took place at three stations along the Wheel Creek main stem and tributaries (WC002, WC003, and WC004). Nutrient synoptic sampling took place at eight indicator stations in Wheel Creek Watershed (Figure 2-2) and eight control stations in a nearby reference watershed, a tributary to Winters Run (Figure 2-3).





Figure 2-1. Area map of Wheel Creek Watershed, showing long-term water chemistry monitoring stations



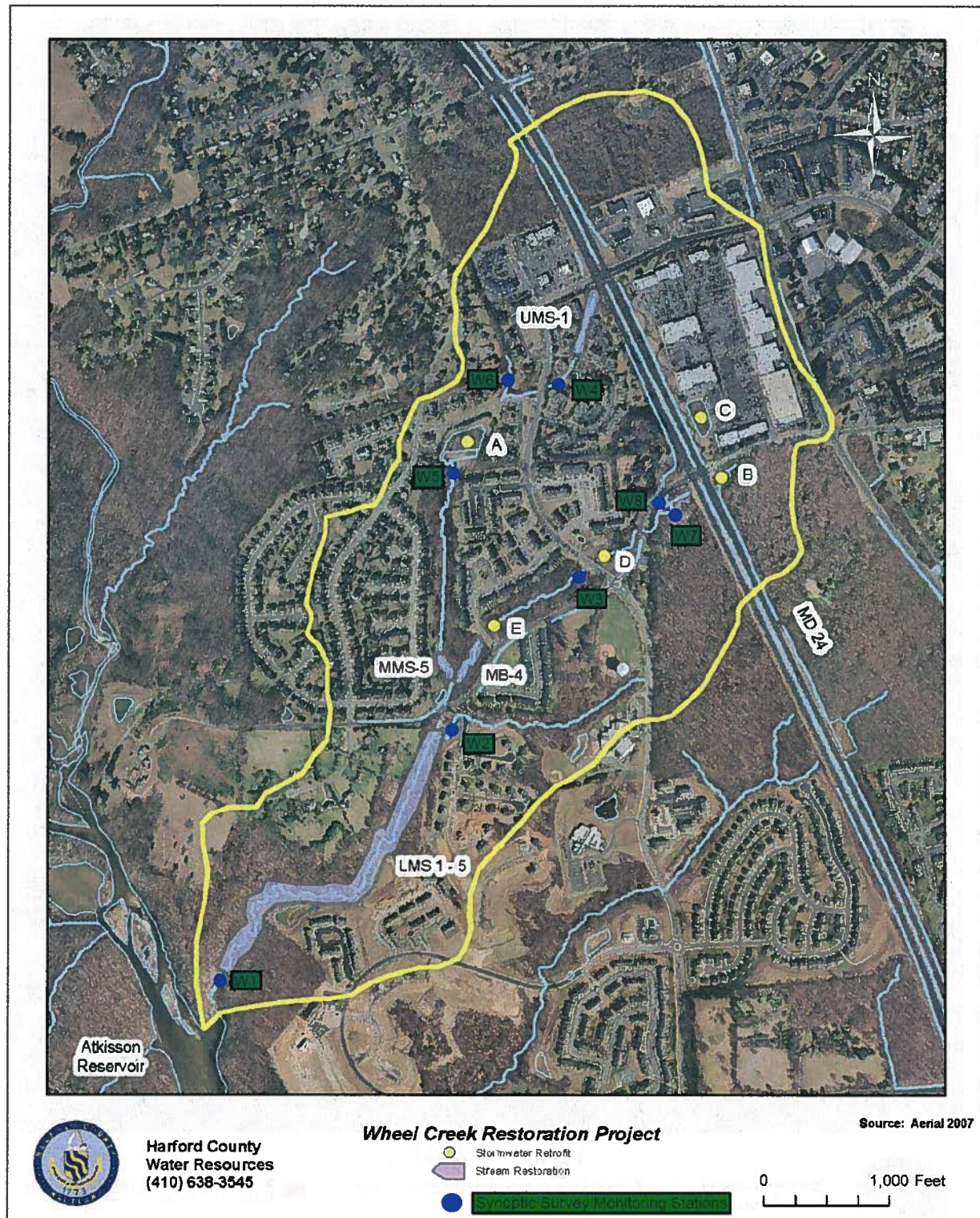


Figure 2-2. Nutrient synoptic sampling stations, stream restoration sites, and stormwater retrofit sites in Wheel Creek watershed



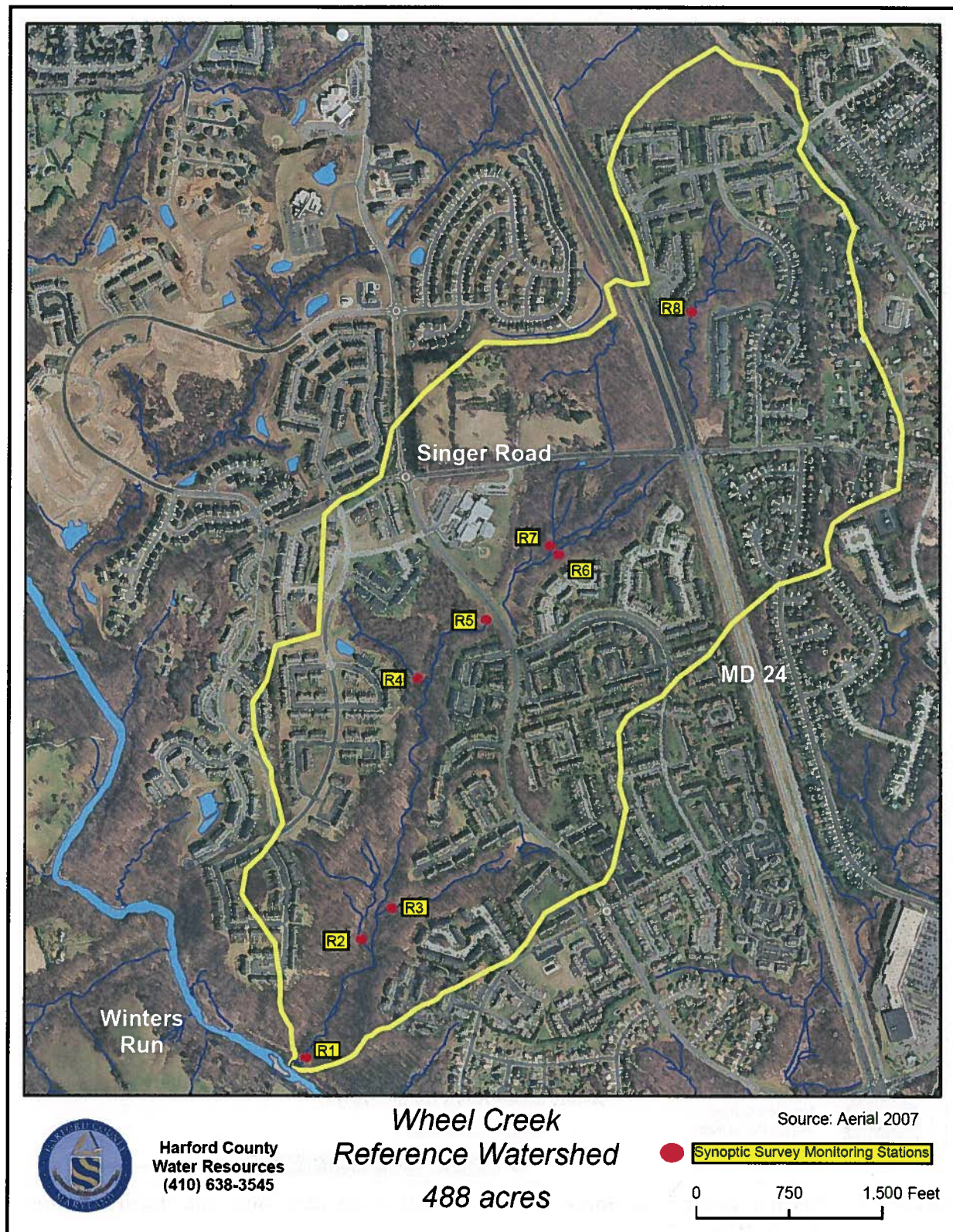


Figure 2-3. Reference synoptic sampling stations



### **3.0 METHODS AND MATERIALS**

#### **3.1 STORMFLOW MONITORING**

Fixed, automated stormflow monitoring and long-term flow logging stations were situated at the following locations:

- WC002 – Wheel Creek mainstem at Wheel Road
- WC003 – Wheel Creek Tributary at Cinnabar Lane
- WC004 – Wheel Creek Tributary off Wheel Court

Stormflow samples were collected by Versar staff using American Sigma 900Max samplers coupled to area-velocity probes at Stations WC002 and WC003, and working in conjunction with a bubbler flowmeter at Station WC004. Automated sampling equipment was installed in September 2010 at Station WC002 and Station WC003 and mid-October 2010 at Station WC004. Area-velocity sensors were secured at the downstream end of culverts at Station WC002 and Station WC003 while the bubbler tube at Station WC004 was secured instream. At Station WC004, an ISCO 4230 bubbler flowmeter was used to record level data. Automated samplers contained 24, one-liter polypropylene bottles and were programmed to start at a specific time (based on the storm forecast) by field staff to sample the rising, peak, and falling limbs of the storm on a time-paced basis. Separate composite samples were created on a discharge volume-proportional basis to represent the rising, peak, and falling limbs of the stream hydrograph.

Ten storms were monitored between February 1 and December 31, 2013 (Table 3-1). Event rainfall duration was calculated from the first to the last measurable amounts of rain which trigger the tipping mechanism within each rain gauge. Antecedent dry time was calculated by determining the time interval between the initiation of rainfall for the monitored event and the cessation of rainfall for the prior event. Qualifying storm events need a minimum of 24 hours where there has been less than 0.03 inches total accumulated rainfall.

Flow rate during monitored storm events was determined using the area-velocity probes at Stations WC002 and WC003 and by rating curve at Station WC004.

The rating curve at Station WC004 was prepared using directly measured flow rates (Appendix B). The flow rate measurements were determined by Versar field staff using a Marsh-McBirney Flowmate 2000 and a wading rod.

Automated storm sampling procedures are described in fuller detail in the project's Quality Assurance and Quality Control Document (Jones and Hage 2011). Stream water samples were tested for the analytes listed in Table 3-2. Analytes with multiple detection limits are presented as a range in Table 3-2.

Table 3-1. Statistics for monitored storms, 2013

Date	Rainfall Total (in.)	Rainfall Duration (hr.)	Antecedent Dry Time (hr.)
26-Feb-13	0.72 <sup>(a)</sup>	17	72
12-Mar-13	0.92 <sup>(b)</sup>	11.75	126
7-May-13	0.49 <sup>(b)</sup>	27.5	170.5
13-Jun-13	0.58 <sup>(a)</sup>	0.5	58.25
1-Aug-13	0.76 <sup>(a)</sup>	5.25	76
21-Sep-13	1.15 <sup>(a)</sup>	11	126.75
18-Nov-13	0.14 <sup>(a)</sup>	4.5	43
26-Nov-13	1.80 <sup>(a)</sup>	30.75	197.75
6-Dec-13	0.75 <sup>(a)</sup>	14.75	200.75
13-Dec-13	0.79 <sup>(a)</sup>	35.75	45.75

<sup>(a)</sup> Rainfall recorded by primary onsite rain gauge at Station WC002

<sup>(b)</sup> Rainfall recorded by backup Darby Lane Weather Underground Station

Table 3-2. Parameters, methods, detection limits, and water quality criteria for Wheel Creek monitoring and nutrient synoptic sampling.

Parameter	Analytical Method	Reportable Detection Limit (mg/l)	Wheel Creek Storm and Baseflow	Nutrient Synoptic Sampling	MD Freshwater Criteria <sup>(a)</sup>		EPA Recommended Ambient Water Quality Criteria <sup>(b)</sup> (mg/l)
					Acute (mg/l)	Chronic (mg/l)	
BOD-5	SM 5210 B	4	√				
Nitrate	EPA 300.0	0.05	√				
Nitrate + Nitrite	EPA 300.0	0.15-0.5	√	√			0.69 (Total N) <sup>(c)</sup>
Total Kjeldahl Nitrogen	EPA 351.2	0.1-0.2	√				
Orthophosphate	SM 4500-P E	0.01-0.05	√	√			
Total Suspended Solids	SM 2540D	4-5	√				
Copper	EPA 200.7	0.00043-0.005	√		0.013	0.009	
Lead	EPA 200.7	0.00049-0.01	√		0.065	0.0025	
Zinc	EPA 200.7	0.000638-0.005	√		0.12	0.12	
Ammonia	SM 4500 NH3G	0.099-0.2	√				
Total Phosphorus	EPA 365.2	0.01-0.05	√				0.03656
Total Petroleum Hydrocarbons	EPA 1664	1.89-7.2	√				
<i>E. coli</i> (reported as MPN/100 ml)	SM 9223B	1	√				

<sup>(a)</sup> Values from COMAR 26.08.02.03-2 (undated).

<sup>(b)</sup> USEPA 2000. Recommended criteria are derived from the 25<sup>th</sup> percentile of concentrations in all streams in the ecoregion.

<sup>(c)</sup> Total nitrogen concentration is the sum of TKN and combined nitrate and nitrite.

Storm event mean concentrations (EMCs) were calculated individually for each storm by obtaining the concentration of each pollutant, weighted according to limb discharge volume (Table 4-4). Limb discharges were determined by plotting the portion of the storm hydrograph represented by the composite sample and integrating under the curve using Flowlink software. For TPH and *E. coli*, which were collected by grab during irregular occasions<sup>1</sup> during stormflow, a simple average concentration without flow weighting was calculated ("greater than" *E. coli* results were set to the numerical result).

For the February 26 and May 7 storms during which flow logging at WC002 was lost, limb discharges were estimated by obtaining the linear regression of the limb discharges at Station WC002 and at Station WC004 for the March 12 and June 13 events with error-free flow logging. The regression had good correlation (95.2%) and the equation of the regression line was used. The same regression method was used to correct irregular flow rate data at Station WC003 during the November 26 storm and erratic flow data recorded at station WC002 for the November 18 and 26 storm events. DNR long term monitoring flow rate data were used to calculate limb discharges at station WC004.

Estimated pollutant loading values were determined by multiplying the storm EMCs by the total storm discharge in cubic feet (Table 4-5). Total storm discharge was determined by plotting the hydrograph and integrating under the curve using Flowlink software. Total discharges at Station WC002 for the February 26, May 7, September 21, November 18, and November 26 storm events and Station WC003 for the November 26 storm event were estimated using a similar regression as described above.

### **3.2 BASEFLOW MONITORING**

Baseflow monitoring was undertaken monthly by DPW staff. Samples were taken at the locations listed below by grab.

- WC002 – Wheel Creek mainstem at Wheel Road
- WC003 – Wheel Creek Tributary at Cinnabar Lane
- WC004 – Wheel Creek Tributary off Wheel Court

### **3.3 NUTRIENT SYNOPTIC SAMPLING**

Nutrient synoptic sampling was conducted by DPW staff during spring 2013 throughout the Wheel Creek Watershed and the reference watershed for orthophosphate and combined nitrate and nitrite. The reference watershed was selected because it is similar in size to, is in close proximity to, contained similar soils as, and contained a similar level of development to Wheel Creek Watershed, but in which no restoration is planned. Sampling was conducted by

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<sup>1</sup> Grab or "first flush" samples were taken during occasions when stormflow was apparent and between daylight and late evening hours.

grab. Instantaneous flow rate measurements were determined by DPW staff using a Marsh-McBirney Flowmate 2000 and a wading rod. Daily baseflow discharge rates (in CF/day) and nutrient export yields (in kg/ha/day) were computed and compared with literature values to categorize nutrient levels at the stations as baseline, moderate, high, or excessive (Table 3-3).

Table 3-3. Nutrient synoptic sampling nutrient ranges and rating (Frink 1991).				
Rating	NO <sub>2</sub> + NO <sub>3</sub> Concentration (mg/l)	NO <sub>2</sub> + NO <sub>3</sub> Yield (kg/ha/day)	Orthophosphate Concentration (mg/l)	Orthophosphate Yield (kg/ha/day)
Baseline	< 1	< 0.01	< 0.005	< 0.0005
Moderate	1 to 3	0.01 to 0.02	0.005 to 0.01	0.0005 to 0.001
High	3 to 5	0.02 to 0.03	0.01 to 0.015	0.001 to 0.002
Excessive	> 5	> 0.03	> 0.015	> 0.002

### 3.4 LONG-TERM FLOW RATE LOGGING

Long-term flow rate logging stations were located at WC002, WC003, and WC004 described above. Maryland Department of Natural Resources (DNR) installed the flow loggers in 2010 and maintained them through 2013. Flow rate data, from October 2012 through December 2013, at Stations WC003 and WC004 were provided to Harford County by DNR in 2014. No flow rate data for Station WC002 were provided due to questionable validity of data recorded.

### 3.5 RAINFALL LOGGING

Rainfall was recorded by an Onset HOBO electronic, tipping-bucket rain gauge situated in an open area near Station WC002. The gauge was downloaded and maintained by Versar field staff and is the primary gauge used for storm event rainfall totals. Daily rainfall recorded by the gauge is presented in Appendix C. Rainfall records from USGS' Atkisson Reservoir gauge (0.8 miles away to the SW), the secondary rainfall recorder, were used to supplement the onsite data in cases where they were unavailable due to power interruptions. Rainfall records from Darby Lane Weather Underground Station were used to supplement USGS' Atkisson Reservoir gauge data in cases where temporary data had expired and were not available for public use.

### 3.6 DETERMINATION OF POLLUTANT LOADS

Pollutant loads were determined by multiplying the pollutant event mean concentration (a stream flow volume-weighted mean of analytical results from laboratory analysis) by the total storm discharge at the point of sample collection. Stream discharge volume for a specific time



interval (for a specific limb or the total event) is determined by integrating under the flow rate hydrograph over the time period of interest.

The pollutant event mean concentration (EMC) for a given storm is determined by:

$$EMC = \frac{\sum_{i=1}^3 C_i V_i}{\sum_{i=1}^3 V_i}$$

Where:

EMC = Event Mean Concentration of specific pollutant

$i$  = Numerical representation of storm limb (1=rising, 2=peak, 3=falling)

$C_i$  = Pollutant concentration at limb  $i$

$V_i$  = Corresponding discharge represented by composite sample collected for limb  $i$ .

The average pollutant EMC for the monitoring year is an arithmetic mean of individual storm EMCs.

Pollutant load for a given storm is calculated by:

$$L = (k_1 / k_2) \times (EMC \times V_T)$$

Where:

$L$  = estimated load in pounds

$k_1$  = conversion factor 28.317 liters per cubic foot

$k_2$  = conversion factor of 453592.4 milligrams per pound

$V_T$  = estimated total storm runoff in stream in  $ft^3$

The average pollutant load for the monitoring year is an arithmetic mean of individual storm loads.

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## 4.0 RESULTS AND DISCUSSION

Results of stormflow, baseflow, and synoptic sampling performed in 2013 are presented and discussed in this section. The individual sample analytical data are compiled into tables while annual average concentrations and loadings are presented in tabular and graphical form.

### 4.1 STORMFLOW CONCENTRATION RESULTS

Storm sample analytical results are presented in Table 4-1. Total nitrogen results were greater than the EPA recommended reference value of 0.69 mg/l (U.S. EPA 2000) in 99% of the samples. Of the samples in which phosphorus was detected, 85% of the results were greater than the EPA recommended reference value of 0.03656 mg/l. Orthophosphate was detected in 85% of all stormflow samples collected at all stations. Ammonia results were above the detection limit in 53% of stormflow samples taken at all stations during the year.

As was the case in the three prior monitoring years, zinc was detected in all stormflow samples. However, 97% of zinc concentrations were less than MDE's acute criterion for surface water (Table 3-2).<sup>2</sup> Lead concentrations were above the detection limit in 89% of the samples. Copper concentrations were above the detection limit in all samples however, only 7.8% were greater than the MDE acute criterion for surface water.

*E. coli* concentrations were equal to or above the maximum reportable limit (2420 MPN/100ml) in 38% of stormflow grab samples. TPH was not detected in any of the 21 stormflow grab samples collected at the monitoring stations.

Storm sample analytical results for filtered samples are presented in Table 4-2. Note that filtering did not begin until May 2013. Filtered TKN was detected in all but one sample (Station WC002) while nitrate and nitrite was detected in all samples at all stations. Total nitrogen results were comparable to unfiltered samples in that they were greater than the EPA recommended reference value of 0.69 mg/l in 95.8% of samples. When detected, phosphorus was greater than the EPA recommended reference value of 0.03656 mg/l in 40.7% of samples.

Note that due to reduced laboratory hours over the Thanksgiving holiday, the November 26 storm event samples exceeded their hold times and some analytes could not be tested. Therefore, no analytical results for orthophosphate, ammonia, and nitrate are presented.

### 4.2 BASEFLOW CONCENTRATION RESULTS

Baseflow sample analytical results are presented in Table 4-3. Baseflow total nitrogen concentrations were greater than the EPA reference value in 100% of samples. Phosphorus and

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<sup>2</sup> The zinc (as well as lead and copper) criterion is based on the dissolved form, while the laboratory analytical results are for total copper concentration.

Orthophosphate and Phosphorus were tested 91% of the time during baseflow sampling. Concentration values for Phosphorus were below the detection limit 63% of the time. Orthophosphate was detected in 73% of baseflow samples. Ammonia was detected during baseflow occasionally, occurring in 39% of samples. TSS was infrequently detected, appearing in 12% of baseflow samples.

Zinc was detected in all baseflow samples, however no concentrations were greater than MDE's chronic surface water criterion. Lead was detected in 27% of baseflow samples. Copper analytical concentrations were above detection limits in 97% of samples. In baseflow samples where copper was detected, the concentrations were less than the MDE chronic surface water criterion.

*E. coli* bacteria were present in all baseflow samples at all stations, with half highest counts (in excess of 1,000 MPN/100 ml) occurring in samples taken from Station WC002 and half at Station WC004. TPH was found in just one of 33 baseflow samples taken from the study area during the year.

#### **4.3 BASEFLOW MEAN AND STORM EVENT MEAN CONCENTRATION DATA**

Average annual baseflow concentration and storm event mean concentration values were calculated for each pollutant at each station. Average concentration data computed for each flow type over the course of a year were used to characterize pollutant concentrations during average baseflow conditions or an average stormflow event.

Under baseflow conditions, average concentrations of combined nitrate and nitrite (Figure 4-1), zinc, and *E. coli* were highest at Station WC004 in comparison to the other two stations. Station WC004 was the only station to register an average baseflow TPH concentration. Average baseflow concentrations of phosphorus, orthophosphate (Figure 4-2), lead, copper, TKN, 5-day BOD, and TSS (Figure 4-3) were the highest at Station WC002.

When comparing stations, average stormflow EMCs were highest at Station WC003 for 5-day BOD, orthophosphate, total phosphorous, TSS, copper, lead, zinc, ammonia, and *E. coli* (Figures 4-1 through 4-6). EMC values for TKN (Figure 4-1), and nitrate and nitrite (Figure 4-7) were the highest at Station WC002. No average stormflow EMCs were calculated for TPH because results were all below the detection limit. Average stormflow EMCs exceeded baseflow mean concentrations for all pollutants except in the cases of nitrate and nitrite at all stations and TPH at station WC004.

#### **4.4 STORMFLOW POLLUTANT LOADING DATA**

Pollutant loads for individual storms at each station were calculated from individual stormflow event mean concentration data. Pollutant load represents the quantity of pollutant, in

pounds, that was transported in the stream during the event. For discussion purposes, an average load was determined for each pollutant at each station for storms monitored during 2013.

When comparing stations, average storm loads were highest at Station WC002 for all parameters (Table 4-7). Average loads were lowest at Station WC004 for all parameters. Since discharge volume for a given storm increases with distance downstream, maximum load results at Station WC002 for most parameters are not unexpected.

Average storm loads were also highest at Station WC002 for filtered nitrate and nitrite, filtered TKN, and filtered total phosphorus. Nitrate and nitrite loadings for filtered samples, at all stations, were comparable to unfiltered storm samples while filtered TKN and filtered phosphorus loads were an average of 46% and 25% lower than unfiltered, respectively.

#### **4.5 NUTRIENT SYNOPTIC SAMPLING RESULTS**

Nitrate and nitrite concentrations in samples taken during synoptic sampling in Wheel Creek were in the moderate category with the exception of Station W2, which fell into the baseline category (Table 4-9). The highest nitrogen (in the form of nitrate and nitrite) concentration result was found at Station W8, which is coincident with Station WC004 where the highest average monthly baseflow concentrations occurred. However, the highest nitrogen yield was found at Station W4. Orthophosphate results were all less than detectible concentrations in Wheel Creek. All of the corresponding yields fell into the baseline category.

No orthophosphate concentrations in the reference watershed were below detectible limits during the synoptic sampling. Six of the stations showed moderate levels while two stations (R4 and R8) fell into the excessive category. Five of the nitrate and nitrite concentrations in samples taken from the reference watershed were in the baseline category while the remaining three were in the moderate category. All of the nitrate and nitrite yields in the reference watershed were in the baseline category. The geographic distribution of synoptic nitrogen concentration and yield conditions in Wheel Creek watershed and the reference watershed are illustrated in Figure 4-7 through Figure 4-10. The geographic distribution of synoptic orthophosphate concentration and yield conditions are illustrated in Figure 4-11 through Figure 4-14.

#### **4.6 MONITORING PROBLEMS IDENTIFIED IN 2013**

During the February 26, May 7, and November 18 and 26 storm events, the area velocity probe at Station WC002 malfunctioned due to unknown causes. Data recorded were either erroneous or zero for portions of each event. Flow rate data were estimated to prepare composite samples (see Section 3.1).

During the November 26 storm event, the area velocity probe at Station WC003 also malfunctioned resulting in erroneous data. Similar to Station WC002 errors, flow rate data were estimated to prepare composite samples (see Section 3.1).

Upon downloading the rain gauge on May 8, field staff noted that memory capacity on the instrument was completely full and that current recordings were overwriting previously stored data. Consequently, rainfall data from February 2 to May 8 are unavailable.



Table 4-1. Stormflow water chemistry results, February – December, 2013. All concentrations are in units of mg/l unless indicated.

Storm Date	Limb	Discharge (cf)	5-Day BOD	Ammonia	Nitrate	Nitrate + Nitrite	Ortho-phosphate	TKN	Total P	TSS	Copper	Lead	Zinc	TPH	<i>E. coli</i> (MPN/100 ml)	Total Nitrogen
Station WC002																
26-Feb-13	Rising	14,374*	<2	<0.099	2.43	2.43	0.01	<0.1	<0.01	13.4	0.0018	<0.0004	0.0291	<1.89	45.7	2.53
26-Feb-13	Peak	89,281*	<2	<0.099	0.659	0.659	0.03	0.728	0.14	85.2	0.0089	0.0028	0.0517	N.C.	N.C.	1.387
26-Feb-13	Falling	53,599*	<2	<0.099	0.649	0.649	0.03	0.55	0.0966	35	0.0046	0.0013	0.033	N.C.	N.C.	1.199
12-Mar-13	Rising	10,558	3	0.0517	1.52	1.52	<0.01	0.417	0.0472	17	0.004	0.000643	0.0319	N.C.	N.C.	1.937
12-Mar-13	Peak	80,220	5	0.089	0.559	0.559	0.04	1.11	0.246	175	0.0129	0.0049	0.0735	N.C.	N.C.	1.669
12-Mar-13	Falling	2,565	2	<0.099	1.68	1.68	0.01	0.283	0.0245	5.6	0.0018	<0.0004	0.031	N.C.	N.C.	1.963
7-May-13	Rising	12,111*	3	0.106	N.T.	N.T.	<0.01	0.59	<0.01	<5	0.0035	<0.0004	0.0223	<1.89	2420	1.89
7-May-13	Peak	32,951*	5	0.147	N.T.	N.T.	<0.01	2.14	0.0714	12.5	0.0075	0.000434	0.0273	N.C.	N.C.	24.84
7-May-13	Falling	17,601*	4	0.0965	N.T.	N.T.	0.02	1.17	0.0729	31.5	0.0077	0.000715	0.0325	N.C.	N.C.	2.037
13-Jun-13	Rising	10,454	8	0.182	1.35	1.35	0.05	1.2	0.218	129	0.0088	0.0031	0.0519	<1.89	>2420	2.55
13-Jun-13	Peak	85,891	9	0.135	0.703	0.703	0.06	1.54	0.284	117	0.0099	0.0037	0.0513	N.C.	N.C.	2.243
13-Jun-13	Falling	18,370	6	0.0859	0.737	0.737	0.15	0.582	0.0936	26.5	0.0049	0.0011	0.0328	N.C.	N.C.	1.319
1-Aug-13	Rising	22,375	8	0.0562	1.3	1.3	0.07	2.63	0.312	94.5	0.0088	0.0025	0.0644	N.C.	N.C.	3.93
1-Aug-13	Peak	38,313	8	<0.099	0.905	0.905	0.07	1.02	0.209	107	0.0127	0.0048	0.0855	N.C.	N.C.	1.925
1-Aug-13	Falling	19,691	3	<0.099	0.749	0.749	0.03	0.318	0.0403	7.5	0.0034	0.00062	0.0236	N.C.	N.C.	1.067
21-Sep-13	Rising	6,747	12	<0.099	2.09	2.09	0.07	0.775	0.191	83.7	0.0059	0.0033	0.063	<1.89	>2420	2.865
21-Sep-13	Peak	50,298	7	<0.099	0.694	0.694	0.06	0.693	0.124	28	0.0047	0.0025	0.0388	N.C.	N.C.	1.387
21-Sep-13	Falling	7,803	<2	<0.099	1.52	1.52	0.02	0.224	0.0202	<5	0.001	0.0029	0.0204	N.C.	N.C.	1.744
18-Nov-13	Rising	11,060*	10	<0.099	2.97	2.97	0.01	0.846	<0.01	11.5	0.0035	<0.0004	0.0378	<1.89	727	3.816
18-Nov-13	Peak	29,477*	10	<0.099	0.994	0.994	0.01	0.394	0.0295	11.8	0.0029	<0.0004	0.0349	N.C.	N.C.	1.388
18-Nov-13	Falling	19,411*	<2	<0.099	0.779	0.779	<0.01	0.384	<0.05	<5	0.0063	0.0014	0.0445	N.C.	N.C.	1.163
26-Nov-13	Rising	42,252*	N.T.	<0.099	N.T.	N.T.	N.T.	0.347	0.029	9.6	0.003	0.00083	0.0334	<1.89	29.2	2.327
26-Nov-13	Peak	245,535*	N.T.	<0.099	N.T.	N.T.	N.T.	1.16	0.202	79.8	0.008	0.0022	0.0635	N.C.	N.C.	1.822
26-Nov-13	Falling	155,017*	N.T.	<0.099	N.T.	N.T.	N.T.	0.498	0.088	17.4	0.0047	0.000954	0.0415	N.C.	N.C.	1.259
6-Dec-13	Rising	8,477	5	<0.099	0.968	0.968	<0.01	0.248	0.0145	<5	0.0037	0.000406	0.0336	<1.89	1050	1.216
6-Dec-13	Peak	40,390	<2	0.112	0.579	0.579	0.03	0.372	<0.01	6.5	0.0068	0.00068	0.0333	N.C.	N.C.	0.951
6-Dec-13	Falling	43,315	<2	0.114	0.602	0.602	0.02	0.453	0.0688	<5	0.0045	0.000583	0.0308	N.C.	N.C.	1.055
13-Dec-13	Rising	13,624	<2	0.207	1.74	1.74	0.02	0.569	0.0359	14.5	0.0031	0.000754	0.0584	N.C.	N.C.	2.309
13-Dec-13	Peak	63,511	7	0.1	0.548	0.548	0.05	0.997	0.157	73	0.008	0.0028	0.0593	N.C.	N.C.	1.545
13-Dec-13	Falling	38,304	5	<0.099	0.687	0.687	0.03	0.514	0.0745	16.5	0.004	0.000917	0.044	N.C.	N.C.	1.201

N.C. = Sample Not Collected

N.T. = Analyte Not Tested

\* = Estimated flow volume



Table 4-1. (Continued).

Storm Date	Limb	Discharge (cf)	5-Day BOD	Ammonia	Nitrate	Nitrate + Nitrite	Ortho-phosphate	TKN	Total P	TSS	Copper	Lead	Zinc	TPH	E. coli (MPN/100 ml)	Total Nitrogen
Station WC003																
26-Feb-13	Rising	3,128	3	< 0.099	1.87	1.87	0.02	0.518	0.0752	61	0.0063	0.0016	0.0602	< 1.89	27.2	2.388
26-Feb-13	Peak	37,534	< 2	0.0523	0.544	0.544	0.05	0.759	0.129	82.3	0.0097	0.0031	0.0578	N.C.	N.C.	1.303
26-Feb-13	Falling	18,429	3	< 0.099	0.626	0.626	0.02	0.407	0.0419	16	0.0041	0.00087	0.0335	N.C.	N.C.	1.033
12-Mar-13	Rising	4,194	2	0.0603	1.2	1.2	0.01	0.41	0.0496	30.4	0.0045	0.000911	0.0308	N.C.	N.C.	1.61
12-Mar-13	Peak	35,182	4	0.0616	0.604	0.604	0.06	1.1	0.259	188	0.0158	0.0058	0.0816	N.C.	N.C.	1.704
12-Mar-13	Falling	618	< 2	< 0.099	1.49	1.49	0.01	< 0.1	< 0.01	< 5	0.0026	< 0.0004	0.034	N.C.	N.C.	1.59
7-May-13	Rising	5,535	< 2	0.122	N.T.	1.52	< 0.01	1.24	0.0375	8.5	0.0061	0.000439	0.0368	< 1.89	1550	2.76
7-May-13	Peak	13,770	2	0.147	N.T.	0.902	< 0.01	0.734	0.0651	18	0.0065	0.000666	0.0323	N.C.	N.C.	1.636
7-May-13	Falling	5,805	< 2	0.137	N.T.	0.913	< 0.01	0.542	0.0454	12.5	0.0059	0.000607	0.031	N.C.	N.C.	1.455
13-Jun-13	Rising	16,505	13	0.11	0.911	0.911	0.06	1.54	0.32	211	0.0171	0.0074	0.0968	< 1.89	> 2420	2.451
13-Jun-13	Peak	40,266	29	0.119	0.593	0.593	0.06	0.424	0.054	55.5	0.0034	0.000755	0.0266	N.C.	N.C.	1.017
13-Jun-13	Falling	5,665	< 2	0.0739	0.85	0.85	0.02	0.818	0.129	12.2	0.008	0.002	0.0446	N.C.	N.C.	1.668
1-Aug-13	Rising	7,574	8	0.0626	1.16	1.16	0.07	1.3	0.251	99.8	0.0116	0.0041	0.0938	N.C.	N.C.	2.46
1-Aug-13	Peak	24,695	7	0.0735	0.626	0.626	0.07	1.03	0.217	93.3	0.0122	0.0042	0.0769	N.C.	N.C.	1.656
1-Aug-13	Falling	5,850	4	0.111	0.62	0.62	0.04	0.335	0.0551	14.3	0.0037	0.00075	0.0304	N.C.	N.C.	0.955
21-Sep-13	Rising	2,738	12	0.148	1.74	1.74	0.11	1.02	0.368	200	0.0127	0.0079	0.136	< 1.89	> 2420	2.76
21-Sep-13	Peak	25,729	14	< 0.099	0.826	0.826	0.11	1.69	0.408	185	0.0175	0.0082	0.133	N.C.	N.C.	2.516
21-Sep-13	Falling	31,131	8	0.113	0.719	0.719	0.07	0.529	0.109	14.6	0.0041	0.0033	0.0334	N.C.	N.C.	1.248
18-Nov-13	Rising	1,896	14	< 0.099	0.925	0.925	0.03	0.476	0.0994	39.5	0.0049	0.0012	0.0592	< 1.89	1050	1.401
18-Nov-13	Peak	4,607	10	< 0.099	1.29	1.29	0.01	0.292	0.0255	9	0.0021	0.0013	0.0459	N.C.	N.C.	1.582
18-Nov-13	Falling	1,508	7	< 0.099	0.727	0.727	< 0.01	0.218	< 0.01	< 5	0.0024	< 0.0004	0.0294	N.C.	N.C.	0.945
26-Nov-13	Rising	20,432*	N.T.	< 0.099	N.T.	1.84	N.T.	0.492	0.065	25.6	0.0035	0.000819	0.0524	< 1.89	1300	2.332
26-Nov-13	Peak	119,532*	N.T.	< 0.099	N.T.	0.828	N.T.	0.801	0.148	31.4	0.0061	0.0021	0.0488	N.C.	N.C.	1.629
26-Nov-13	Falling	75,405*	N.T.	< 0.099	N.T.	0.925	N.T.	0.611	0.103	16	0.005	0.0013	0.0381	N.C.	N.C.	1.536
6-Dec-13	Rising	12,183	14	< 0.099	0.674	0.674	< 0.01	0.372	0.042	9	0.0047	0.000645	0.0405	< 1.89	1550	1.046
6-Dec-13	Peak	38,029	< 2	0.172	0.594	0.594	0.02	0.347	0.0454	< 5	0.005	0.000634	0.0332	N.C.	N.C.	0.941
6-Dec-13	Falling	24,002	< 2	0.103	0.502	0.502	0.02	0.408	0.0475	< 5	0.0046	0.00053	0.0327	N.C.	N.C.	0.91
13-Dec-13	Rising	9,105	5	0.213	1.37	1.37	0.02	0.8	0.0841	39.3	0.0059	0.0017	0.104	N.C.	N.C.	2.17
13-Dec-13	Peak	46,145	5	< 0.099	0.622	0.622	0.03	0.778	0.146	44.3	0.0071	0.002	0.0605	N.C.	N.C.	1.4
13-Dec-13	Falling	28,574	< 2	< 0.099	0.603	0.603	0.03	0.368	0.0421	< 5	0.0036	0.000663	0.042	N.C.	N.C.	0.971

N.C. = Sample Not Collected

N.T. = Analyte Not Tested

\* = Estimated flow volume

Table 4-1. (Continued).

Storm Date	Limb	Discharge (cf)	S-Day BOD	Ammonia	Nitrate	Nitrate + Nitrite	Ortho-phosphate	TKN	Total P	TSS	Copper	Lead	Zinc	TPH	E. coli (MPN/100 ml)	Total Nitrogen
Station WC004																
26-Feb-13	Rising	2,786	5	0.111	1.02	1.02	0.03	0.933	0.0939	30	0.0155	0.0029	0.0825	<1.89	22.3	1.953
26-Feb-13	Peak	17,685	<2	<0.099	0.435	0.435	0.03	0.327	0.0635	24.6	0.0065	0.0015	0.0486	N.C.	N.C.	0.762
26-Feb-13	Falling	10,588	<2	<0.099	0.532	0.532	0.01	0.327	0.0283	5.4	0.0025	<0.0004	0.0266	N.C.	N.C.	0.859
12-Mar-13	Rising	4,340	3	0.118	0.782	0.782	0.02	0.721	0.102	66.4	0.0083	0.0023	0.061	N.C.	N.C.	1.503
12-Mar-13	Peak	14,348	<2	<0.099	0.488	0.488	0.05	0.398	0.0768	41.2	0.0064	0.002	0.0432	N.C.	N.C.	0.886
12-Mar-13	Falling	180	<2	0.0694	2.24	2.24	0.01	<0.1	<0.01	<5	0.0022	<0.0004	0.036	N.C.	N.C.	2.34
7-May-13	Rising	2,336	5	0.141	N.T.	1.24	0.03	1.18	0.176	82.8	0.0168	0.003	0.0755	<1.89	1120	2.42
7-May-13	Peak	6,481	2	0.139	N.T.	0.74	0.05	0.687	0.116	25.5	0.0091	0.0012	0.0452	N.C.	N.C.	1.427
7-May-13	Falling	3,428	2	0.137	N.T.	0.716	<0.01	0.501	0.0438	7.8	0.0077	0.000569	0.0394	N.C.	N.C.	1.217
13-Jun-13	Rising	123	12	0.083	0.865	0.865	0.06	2.02	0.393	151	0.0163	0.0069	0.104	<1.89	>2420	2.885
13-Jun-13	Peak	18,616	7	0.0502	0.571	0.571	0.03	0.875	0.104	29.6	0.0059	0.0016	0.0327	N.C.	N.C.	1.446
13-Jun-13	Falling	4,215	<2	0.125	0.76	0.76	0.04	0.325	0.0323	7.2	0.003	0.000532	0.0287	N.C.	N.C.	1.085
1-Aug-13	Rising	11,020	9	<0.099	0.606	0.606	0.14	1.41	0.322	131	0.0198	0.0086	0.129	N.C.	N.C.	2.016
1-Aug-13	Peak	25,438	3	<0.099	0.457	0.457	0.05	0.63	0.0758	24.5	0.0053	0.0012	0.0334	N.C.	N.C.	1.087
1-Aug-13	Falling	11,573	<2	0.0896	0.521	0.521	0.04	0.466	0.0606	9	0.0031	0.000484	0.0325	N.C.	N.C.	0.987
21-Sep-13	Rising	7,568	8	<0.099	0.874	1.14	0.07	0.953	0.211	63	0.0112	0.0042	0.0902	<1.89	1200	2.093
21-Sep-13	Peak	13,158	<2	0.178	0.463	0.463	0.06	0.667	0.122	29.2	0.0046	0.0013	0.0374	N.C.	N.C.	1.13
21-Sep-13	Falling	8,949	5	<0.099	0.544	0.544	0.05	0.401	0.0713	18.6	0.0032	0.000986	0.04	N.C.	N.C.	0.945
18-Nov-13	Rising	2,127	10	0.102	1.5	1.5	<0.01	0.472	0.0448	15	0.0062	0.0021	0.0527	<1.89	>2420	1.972
18-Nov-13	Peak	5,790	<2	<0.099	0.793	0.793	0.02	0.295	0.0332	4.6	0.004	0.000639	0.0332	N.C.	N.C.	1.088
18-Nov-13	Falling	3,788	<2	<0.099	0.837	0.837	0.02	0.246	0.0222	<5	0.0045	<0.0004	0.0384	N.C.	N.C.	1.083
26-Nov-13	Rising	8,331	N.T.	0.13	N.T.	0.798	N.T.	0.854	0.123	22.4	0.0068	0.0026	0.0468	<1.89	54.6	1.652
26-Nov-13	Peak	48,764	N.T.	<0.099	N.T.	1.2	N.T.	0.521	0.079	14.8	0.0037	0.0011	0.0349	N.C.	N.C.	1.721
26-Nov-13	Falling	30,760	N.T.	<0.099	N.T.	0.642	N.T.	0.263	0.026	<5	0.0025	0.000705	0.0317	N.C.	N.C.	0.905
6-Dec-13	Rising	326	21	0.109	0.635	0.635	0.01	1.19	0.286	177	0.0228	0.0076	0.116	<1.89	2420	1.825
6-Dec-13	Peak	11,548	<2	0.152	0.402	0.402	0.02	0.304	0.049	10.8	0.0054	0.000938	0.0389	N.C.	N.C.	0.706
6-Dec-13	Falling	11,918	<2	0.134	0.366	0.366	0.02	0.204	0.0313	5.5	0.0056	0.000653	0.0415	N.C.	N.C.	0.57
13-Dec-13	Rising	1,790	5	0.202	0.676	0.676	0.03	0.815	0.103	29	0.0095	0.0025	0.102	N.C.	N.C.	1.491
13-Dec-13	Peak	34,157	4	<0.099	0.496	0.496	0.04	0.503	0.0991	37.6	0.0067	0.0019	0.0567	N.C.	N.C.	0.999
13-Dec-13	Falling	11,482	<2	0.122	0.434	0.434	0.02	0.293	0.0419	16	0.0031	0.0013	0.0577	N.C.	N.C.	0.727

N.C. = Sample Not Collected

N.T. = Analyte Not Tested

\* = Estimated flow volume

Table 4-2. Stormflow filtered water chemistry results, February – December, 2013. All concentrations are in units of mg/l unless indicated.

Station		WC002				WC003				WC004			
Storm Date	Limb	Discharge (cf)	Nitrate + Nitrite	TKN	Total P	Discharge (cf)	Nitrate + Nitrite	TKN	Total P	Discharge (cf)	Nitrate + Nitrite	TKN	Total P
26-Feb-13	Rising	14,374*	N.C.	N.C.	N.C.	3,128	N.C.	N.C.	N.C.	2,786	N.C.	N.C.	N.C.
26-Feb-13	Peak	89,281*	N.C.	N.C.	N.C.	37,534	N.C.	N.C.	N.C.	17,685	N.C.	N.C.	N.C.
26-Feb-13	Falling	53,599*	N.C.	N.C.	N.C.	18,429	N.C.	N.C.	N.C.	10,588	N.C.	N.C.	N.C.
12-Mar-13	Rising	10,558	N.C.	N.C.	N.C.	4,194	N.C.	N.C.	N.C.	4,340	N.C.	N.C.	N.C.
12-Mar-13	Peak	80,220	N.C.	N.C.	N.C.	35,182	N.C.	N.C.	N.C.	14,348	N.C.	N.C.	N.C.
12-Mar-13	Falling	2,565	N.C.	N.C.	N.C.	618	N.C.	N.C.	N.C.	180	N.C.	N.C.	N.C.
7-May-13	Rising	12,111*	0.87	1.19	< 0.01	5,535	1.27	1.1	0.148	2,336	1.03	1.43	0.055
7-May-13	Peak	32,951*	1.12	1.17	0.055	13,770	0.67	0.94	0.026	6,481	0.49	0.89	0.05
7-May-13	Falling	17,601*	0.64	0.78	0.06	5,805	0.55	0.84	0.05	3,428	0.48	0.98	0.041
13-Jun-13	Rising	10,454	1.24	0.421	0.0184	16,505	0.90	0.415	0.0274	123	0.762	0.549	0.0386
13-Jun-13	Peak	85,891	0.799	0.667	0.0451	40,266	0.778	0.33	0.0145	18,616	0.571	0.328	0.0359
13-Jun-13	Falling	18,370	0.801	0.496	0.0319	5,665	0.657	0.524	0.0397	4,215	0.66	0.271	0.0119
1-Aug-13	Rising	22,375	1.19	0.376	0.0116	7,574	1.06	0.342	< 0.01	11,020	0.676	0.334	0.0116
1-Aug-13	Peak	38,313	0.791	0.221	0.0297	24,695	0.694	0.444	0.024	25,438	0.441	0.407	0.0282
1-Aug-13	Falling	19,691	0.707	0.403	0.022	5,850	0.597	0.425	0.0206	11,573	0.527	0.296	0.0263
21-Sep-13	Rising	6,747	2.03	0.292	0.045	2,738	1.71	0.319	0.262	7,568	0.554	0.486	0.042
21-Sep-13	Peak	50,298	0.799	0.415	0.0503	25,729	0.707	0.243	0.019	13,158	0.435	0.389	0.043
21-Sep-13	Falling	7,803	1.47	0.21	< 0.01	31,131	0.694	0.537	0.0583	8,949	0.427	0.318	0.0297
18-Nov-13	Rising	11,060*	1.45	0.179	< 0.01	1,896	0.943	0.125	< 0.01	2,127	1.63	0.53	0.01
18-Nov-13	Peak	29,477*	1.15	0.141	< 0.01	4,607	1.24	0.237	< 0.01	5,790	0.735	0.148	< 0.01
18-Nov-13	Falling	19,411*	0.805	0.197	< 0.01	1,508	0.855	0.154	< 0.01	3,788	0.988	0.257	< 0.01
26-Nov-13	Rising	42,252*	1.58	0.321	< 0.01	20,432*	2.02	0.236	< 0.01	8,331	0.777	0.323	0.0249
26-Nov-13	Peak	245,535*	0.688	0.297	0.0269	119,532*	0.751	0.438	0.053	48,764	0.875	0.213	0.0417
26-Nov-13	Falling	155,017*	0.922	0.239	0.0438	75,405*	1.41	0.336	0.0601	30,760	0.639	0.174	0.024
6-Dec-13	Rising	8,477	1.41	< 0.1	< 0.01	12,183	0.711	0.212	< 0.01	326	0.678	0.175	< 0.01
6-Dec-13	Peak	40,390	0.818	0.35	0.0298	38,029	0.617	0.308	0.0266	11,548	0.461	0.168	0.016
6-Dec-13	Falling	43,315	0.656	0.346	0.0371	24,002	0.618	0.262	0.0237	11,918	0.437	0.181	0.0116
13-Dec-12	Rising	13,624	1.66	0.372	0.0123	9,105	1.35	0.382	0.0107	1,790	0.718	0.344	0.0191
13-Dec-12	Peak	63,511	0.59	0.331	0.0206	46,145	0.476	0.317	0.0253	34,157	0.541	0.161	0.0186
13-Dec-12	Falling	38,304	0.722	0.309	0.0368	28,574	0.623	0.275	< 0.01	11,482	0.409	0.233	< 0.01

N.C. = Sample Not Collected

\* = Estimated flow volume



Table 4-3. Baseflow water chemistry results, 2013. All concentrations are in units of mg/l unless indicated.

Baseflow Date	5-Day BOD	Ammonia	Nitrate	Nitrate + Nitrite	Ortho-phosphate	TKN	Total P	TSS	Copper	Lead	Zinc	TPH	E. coli (MPN/100 ml)	Total Nitrogen
Station WC002														
31-Jan-13	< 2	< 0.099	0.786	0.786	N.T.	0.751	N.T.	41.8	0.0073	0.0017	0.0452	< 1.89	1550	1.537
20-Feb-13	5	< 0.099	2.78	2.78	< 0.01	0.181	< 0.01	< 5	0.0015	< 0.0004	0.0348	< 1.89	38.3	2.961
14-Mar-13	N.T.	< 0.099	1.94	1.94	0.02	N.T.	< 0.01	< 5	0.0011	< 0.0004	0.0243	< 1.89	98.7	N.A.
24-Apr-13	11	0.063	2.09	2.09	< 0.01	< 0.1	< 0.01	< 5	0.0016	< 0.0004	0.0256	< 1.89	345	2.19
22-May-13	18	0.0896	1.65	1.65	0.02	< 0.1	0.0146	< 5	0.000735	< 0.0004	0.0227	< 1.89	291	1.75
25-Jul-13	< 2	< 0.099	2.12	2.12	0.02	0.222	0.0175	< 5	0.000742	< 0.0004	0.0191	< 1.89	249	2.342
1-Aug-13	< 2	0.088	2.32	2.32	< 0.01	< 0.1	< 0.01	< 5	0.001	0.003	0.0283	< 1.89	44.8	2.42
19-Sep-13	11	< 0.099	2.16	2.16	0.18	1.2	0.369	211	0.0085	0.0065	0.0813	< 1.89	1050	3.36
24-Oct-13	< 2	< 0.099	2.41	2.41	0.02	< 0.1	< 0.01	< 5	0.000763	< 0.0004	0.0352	< 1.89	33.6	2.51
21-Nov-13	< 2	< 0.099	2.61	2.61	0.02	0.159	< 0.01	< 5	0.000882	< 0.0004	0.0233	< 1.89	12.1	2.769
19-Dec-13	< 2	< 0.099	2.64	2.64	0.02	< 0.1	0.0162	< 5	0.00088	< 0.0004	0.0378	< 1.89	28.2	2.74
Station WC003														
31-Jan-13	< 2	0.0774	0.718	0.718	N.T.	0.613	N.T.	14.4	0.0044	0.000819	0.0463	< 1.89	517	1.331
20-Feb-13	< 2	< 0.099	1.86	1.86	< 0.01	0.105	< 0.01	< 5	0.0013	< 0.0004	0.0405	< 1.89	42.6	1.965
14-Mar-13	N.T.	0.0583	1.57	1.57	< 0.01	N.T.	< 0.01	< 5	0.000958	< 0.0004	0.0298	< 1.89	49.6	N.A.
24-Apr-13	< 2	0.106	1.58	1.58	< 0.01	0.21	< 0.01	< 5	0.000755	< 0.0004	0.0265	< 1.89	122	1.79
22-May-13	< 2	0.122	1.58	1.58	0.01	0.25	< 0.01	< 5	0.000893	< 0.0004	0.0309	< 1.89	109	1.83
25-Jul-13	< 2	0.0847	1.69	1.69	0.04	0.222	0.026	< 5	0.00079	< 0.0004	0.0285	< 1.89	172	1.912
1-Aug-13	< 2	0.0539	1.93	1.93	0.01	0.208	0.0186	< 5	0.000844	0.0014	0.0293	< 1.89	119	2.138
19-Sep-13	< 2	< 0.099	1.55	1.55	0.03	0.187	0.0189	< 5	< 0.00043	0.0059	0.0303	< 1.89	206	1.737
24-Oct-13	< 2	< 0.099	1.9	1.9	0.02	< 0.1	< 0.01	< 5	0.0011	< 0.0004	0.0433	< 1.89	95.9	2
21-Nov-13	< 2	< 0.099	2.03	2.03	0.02	< 0.1	0.0109	< 5	0.000609	< 0.0004	0.0362	< 1.89	18.3	2.13
19-Dec-13	< 2	< 0.099	2.04	2.04	0.02	< 0.1	< 0.01	< 5	0.0017	< 0.0004	0.0596	< 1.89	75.4	2.14
Station WC004														
31-Jan-13	< 2	0.152	0.551	0.551	N.T.	0.692	N.T.	7.4	0.0083	0.0019	0.0631	< 1.89	579	1.243
20-Feb-13	2	< 0.099	3.26	3.26	< 0.01	0.162	< 0.01	< 5	0.0025	< 0.0004	0.0637	< 1.89	9.7	3.422
14-Mar-13	N.T.	< 0.099	3.27	3.27	0.01	N.T.	< 0.01	< 5	0.0017	< 0.0004	0.0289	< 1.89	82	N.A.
24-Apr-13	< 2	0.0806	3.61	3.61	< 0.01	0.232	< 0.01	< 5	0.0011	< 0.0004	0.0266	< 1.89	1300	3.842
22-May-13	< 2	0.0751	3.57	3.57	0.05	0.278	0.0144	< 5	0.0014	< 0.0004	0.0284	< 1.89	147	3.848
25-Jul-13	< 2	< 0.099	2.99	2.99	0.02	0.293	< 0.01	< 5	0.0012	< 0.0004	0.0287	< 1.89	1730	3.283
1-Aug-13	< 2	0.0573	4.26	4.26	0.01	< 0.1	0.0167	< 5	0.0011	0.003	0.0268	3.3	51.2	4.36
19-Sep-13	< 2	< 0.099	4.7	4.7	0.02	< 0.1	< 0.01	< 5	0.000592	0.003	0.0308	< 1.89	172	4.8
24-Oct-13	< 2	< 0.099	4.46	4.46	0.01	< 0.1	0.0164	< 5	0.001	< 0.0004	0.0296	< 1.89	248	4.81
21-Nov-13	< 2	< 0.099	4.67	4.67	0.01	< 0.1	< 0.01	< 5	0.0022	< 0.0004	0.0348	< 1.89	35.5	4.77
19-Dec-13	< 2	< 0.099	2.95	2.95	0.02	< 0.1	< 0.01	< 5	0.0018	< 0.0004	0.105	< 1.89	114	3.05
N.T. = Analyte Not Tested														
N.A. = Total not available due to no TKN concentration														

Table 4-4. Storm event mean concentration results (mg/l), February – December, 2013 (non-detects set to zero).

Storm Date	Rainfall (inches)	5-Day BOD	Ammonia	Nitrate	Nitrate + Nitrite	Ortho-phosphate	TKN	Total P	TSS	Copper	Lead	Zinc
Station WC002												
26-Feb-13	0.72	0	0	23.517	23.517	0.810	17.283	3.234	1769.982	0.195	0.058	1.245
12-Mar-13	0.92	225.949	3.966	33.642	33.642	1.669	48.591	10.472	7343.597	0.558	0.206	3.257
7-May-13	0.49	22.649	0.653	N.T.	64.986	0.029	8.197	0.303	80.615	0.035	0.002	0.145
13-Jun-13	0.58	169.175	2.638	15.403	15.403	1.475	27.209	4.968	2079.468	0.181	0.065	0.971
1-Aug-13	0.76	163.860	0.378	23.623	23.623	1.456	31.349	4.749	1914.169	0.226	0.076	1.559
21-Sep-13	1.15	141.600	0	19.903	19.903	1.192	13.679	2.512	645.159	0.093	0.056	0.829
18-Nov-13	0.14	53.469	0	10.192	10.192	0.053	3.749	0.115	62.656	0.033	0.004	0.305
26-Nov-13	1.80	N.T.	0	N.T.	69.349	N.T.	71.731	12.276	4322.097	0.537	0.138	4.463
6-Dec-13	0.75	9.172	2.048	12.479	12.479	0.450	7.953	0.671	56.813	0.108	0.012	0.641
13-Dec-13	0.79	181.043	2.610	24.142	24.142	1.308	25.832	3.789	1555.670	0.200	0.064	1.778
Station WC003												
26-Feb-13	0.72	10.389	0.315	6.073	6.073	0.371	6.042	0.940	574.261	0.074	0.022	0.478
12-Mar-13	0.92	64.287	1.043	11.728	11.728	0.931	17.426	4.018	2906.511	0.248	0.090	1.302
7-May-13	0.49	3.403	0.432	N.T.	3.229	0	2.486	0.169	45.404	0.019	0.002	0.102
13-Jun-13	0.58	163.587	0.831	5.175	5.175	0.417	5.577	0.969	684.800	0.055	0.019	0.346
1-Aug-13	0.76	63.325	0.724	6.871	6.871	0.615	9.182	1.869	775.012	0.101	0.034	0.687
21-Sep-13	1.15	110.181	0.673	8.305	8.305	0.911	10.766	2.556	988.713	0.105	0.058	0.829
18-Nov-13	0.14	26.875	0	2.841	2.841	0.033	0.833	0.099	37.598	0.007	0.003	0.119
26-Nov-13	1.80	N.T.	0	N.T.	31.896	N.T.	23.478	4.141	847.621	0.182	0.057	1.511
6-Dec-13	0.75	32.122	1.697	8.070	8.070	0.234	5.183	0.636	20.650	0.067	0.008	0.479
13-Dec-13	0.79	69.486	0.488	14.691	14.691	0.610	13.507	2.190	604.193	0.122	0.032	1.242
Station WC004												
26-Feb-13	0.72	2.485	0.055	2.884	2.884	0.128	2.113	0.300	102.699	0.033	0.006	0.245
12-Mar-13	0.92	5.657	0.228	4.692	4.692	0.350	3.841	0.671	382.036	0.056	0.017	0.387
7-May-13	0.49	4.434	0.239	N.T.	1.428	0.055	1.257	0.185	54.257	0.018	0.002	0.085
13-Jun-13	0.58	25.321	0.283	2.678	2.678	0.141	3.441	0.407	115.271	0.024	0.006	0.143
1-Aug-13	0.76	17.922	0.106	2.485	2.485	0.335	3.774	0.631	221.705	0.040	0.013	0.270
21-Sep-13	1.15	17.020	0.379	2.841	3.166	0.286	3.165	0.621	166.083	0.028	0.009	0.248
18-Nov-13	0.14	3.922	0.040	2.019	2.019	0.035	0.672	0.069	10.793	0.010	0.002	0.083
26-Nov-13	1.80	N.T.	0.179	N.T.	14.058	N.T.	6.723	0.940	150.380	0.052	0.016	0.508
6-Dec-13	0.75	0.811	0.402	1.092	1.092	0.056	0.750	0.122	29.390	0.016	0.002	0.116
13-Dec-13	0.79	22.162	0.268	3.522	3.522	0.251	3.350	0.617	231.382	0.043	0.013	0.423

N.T. = Analyte Not Tested

Table 4-5. Storm event pollutant loadings (lbs per event), February – December, 2013 (non-detects set to zero).

Storm Date	Discharge (cf)	5-Day BOD	Ammonia	Nitrate	Nitrate + Nitrite	Ortho-phosphate	TKN	Total P	TSS	Copper	Lead	Zinc
Station WC002												
26-Feb-13	460,814*	0	0	23.517	23.517	0.810	17.283	3.234	1769.982	0.195	0.058	1.245
12-Mar-13	771,498	225.949	3.966	33.642	33.642	1.669	48.591	10.472	7343.597	0.558	0.206	3.257
7-May-13	83,738*	22.649	0.653	N.T.	64.986	0.029	8.197	0.303	80.615	0.035	0.002	0.145
13-Jun-13	321,520	169.175	2.638	15.403	15.403	1.475	27.209	4.968	2079.468	0.181	0.065	0.971
1-Aug-13	387,415*	163.860	0.378	23.623	23.623	1.456	31.349	4.749	1914.169	0.226	0.076	1.559
21-Sep-13	339,658	141.600	0	19.903	19.903	1.192	13.679	2.512	645.159	0.093	0.056	0.829
18-Nov-13	126,663*	53.469	0	10.192	10.192	0.053	3.749	0.115	62.656	0.033	0.004	0.305
26-Nov-13	1,350,722*	N.T.	0	N.T.	69.349	N.T.	71.731	12.276	4322.097	0.537	0.138	4.463
6-Dec-13	319,542	9.172	2.048	12.479	12.479	0.450	7.953	0.671	56.813	0.108	0.012	0.641
13-Dec-13	526,298	181.043	2.610	24.142	24.142	1.308	25.832	3.789	1555.670	0.200	0.064	1.778
Station WC003												
26-Feb-13	152,058	10.389	0.315	6.073	6.073	0.371	6.042	0.940	574.261	0.074	0.022	0.478
12-Mar-13	276,196	64.287	1.043	11.728	11.728	0.931	17.426	4.018	2906.511	0.248	0.090	1.302
7-May-13	49,698	3.403	0.432	N.T.	3.229	0.000	2.486	0.169	45.404	0.019	0.002	0.102
13-Jun-13	118,361	163.587	0.831	5.175	5.175	0.417	5.577	0.969	684.800	0.055	0.019	0.346
1-Aug-13	150,538*	63.325	0.724	6.871	6.871	0.615	9.182	1.869	775.012	0.101	0.034	0.687
21-Sep-13	163,814	110.181	0.673	8.305	8.305	0.911	10.766	2.556	988.713	0.105	0.058	0.829
18-Nov-13	41,465*	26.875	0	2.841	2.841	0.033	0.833	0.099	37.598	0.007	0.003	0.119
26-Nov-13	533,334*	N.T.	0	N.T.	31.896	N.T.	23.478	4.141	847.621	0.182	0.057	1.511
6-Dec-13	223,885	32.122	1.697	8.070	8.070	0.234	5.183	0.636	20.650	0.067	0.008	0.479
13-Dec-13	337,740	69.486	0.488	14.691	14.691	0.610	13.507	2.190	604.193	0.122	0.032	1.242
Station WC004												
26-Feb-13	88,736	2.485	0.055	2.884	2.884	0.128	2.113	0.300	102.699	0.033	0.006	0.245
12-Mar-13	131,313	5.657	0.228	4.692	4.692	0.350	3.841	0.671	382.036	0.056	0.017	0.387
7-May-13	27,612	4.434	0.239	N.T.	1.428	0.055	1.257	0.185	54.257	0.018	0.002	0.085
13-Jun-13	70,645	25.321	0.283	2.678	2.678	0.141	3.441	0.407	115.271	0.024	0.006	0.143
1-Aug-13	78,570	17.922	0.106	2.485	2.485	0.335	3.774	0.631	221.705	0.040	0.013	0.270
21-Sep-13	76,838	17.020	0.379	2.841	3.166	0.286	3.165	0.621	166.083	0.028	0.009	0.248
18-Nov-13	34,570	3.922	0.040	2.019	2.019	0.035	0.672	0.069	10.793	0.010	0.002	0.083
26-Nov-13	232,990	N.T.	0.179	N.T.	14.058	N.T.	6.723	0.940	150.380	0.052	0.016	0.508
6-Dec-13	45,170	0.811	0.402	1.092	1.092	0.056	0.750	0.122	29.390	0.016	0.002	0.116
13-Dec-13	115,657	22.162	0.268	3.522	3.522	0.251	3.350	0.617	231.382	0.043	0.013	0.423

N.T. = Analyte Not Tested  
 \* = Estimated total discharge.



Table 4-6. Average storm EMCs and baseflow mean concentrations, Wheel Creek Watershed, 2013 (non-detects set to zero). All concentrations are in units of mg/l unless indicated.

Station	5-Day BOD	Ammonia	Nitrate	Nitrate + Nitrite	Ortho-phosphate	TKN	Total P	TSS	Copper	Lead	Zinc	TPH	<i>E. coli</i> (MPN/100 ml)
Storm EMCs													
WC002	4.849	0.054	0.856	2.010	0.036	0.898	0.126	55.197	0.007	0.002	0.047	0	1301.700
WC003	6.839	0.063	0.742	0.793	0.040	0.727	0.128	58.564	0.008	0.002	0.054	0	1473.886
WC004	2.425	0.055	0.576	0.647	0.037	0.529	0.082	26.039	0.006	0.002	0.045	0	1379.557
MD avg <sup>(a)</sup>	14.44	N.R.	N.R.	0.85	N.R.	1.94	0.33	66.57	0.0179	0.0125	0.1433	N.R.	N.R.
NSQD <sup>(b)</sup>	16.943	N.R.	N.R.	1.587	N.R.	2.921	0.412	111.295	0.042	0.041	0.250	2.759	N.R.
Baseflow Mean Concentrations													
WC002	4.500	0.022	2.137	2.137	0.030	0.251	0.042	22.982	0.002	0.001	0.034	0	340.064
WC003	0	0.046	1.677	1.677	0.015	0.180	0.007	1.309	0.001	0.001	0.036	0	138.800
WC004	0.200	0.033	3.481	3.504	0.015	0.166	0.005	0.673	0.002	0.001	0.042	0.300	406.218

N.R. = Reference data not available.  
<sup>(a)</sup> = Maryland State average values from Bahr 1997.  
<sup>(b)</sup> = National Stormwater Quality Database values for Maryland from Pitt 2008.

Table 4-7. Average storm pollutant loads (lb), Wheel Creek monitoring, 2013 (non-detects set to zero).

Station	5-Day BOD	Ammonia	Nitrate	Nitrate + Nitrite	Ortho-phosphate	TKN	Total P	TSS	Copper	Lead	Zinc
WC002	107.435	1.229	20.363	29.724	0.938	25.557	4.309	1983.022	0.217	0.068	1.519
WC003	60.406	0.620	7.969	9.888	0.458	9.448	1.759	748.476	0.098	0.032	0.710
WC004	11.081	0.218	2.777	3.802	0.182	2.908	0.456	146.400	0.032	0.009	0.251

Table 4-8. Average filtered storm pollutant loads (lb), Wheel Creek monitoring, 2013 (non-detects set to zero).

Station	Nitrate + Nitrite	TKN	Total P
WC002	23.266	9.077	0.827
WC003	10.560	4.675	0.415
WC004	3.358	1.532	0.145

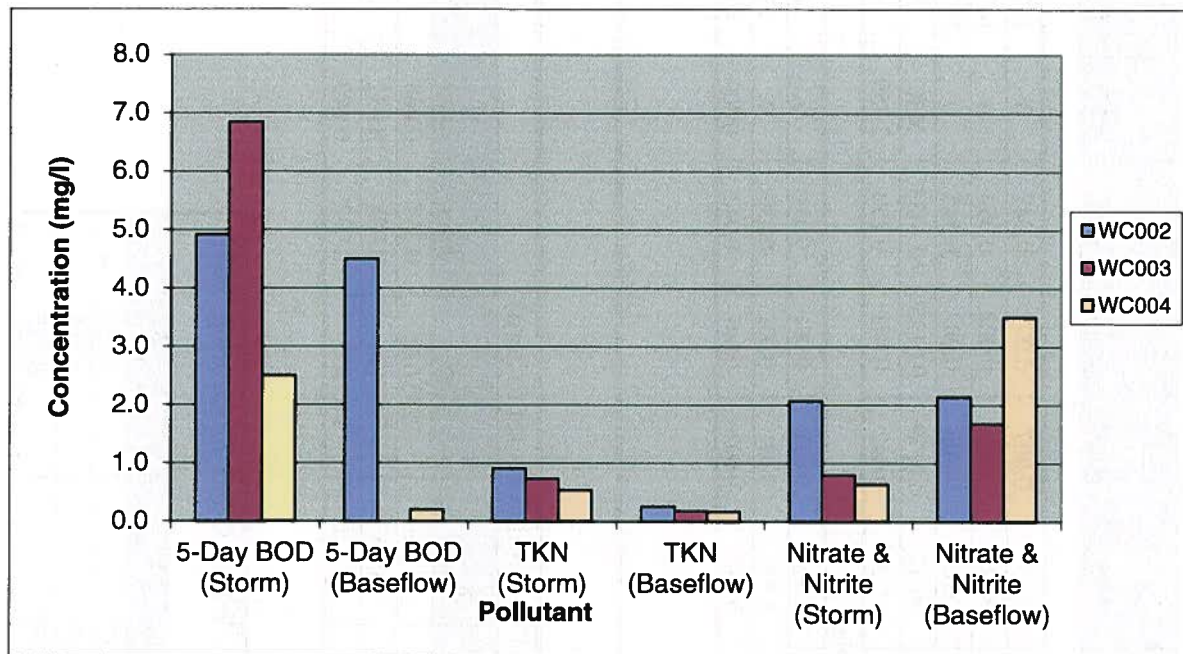


Figure 4-1. Nitrogen and 5-day BOD average storm event mean and baseflow mean concentrations in Wheel Creek, 2013

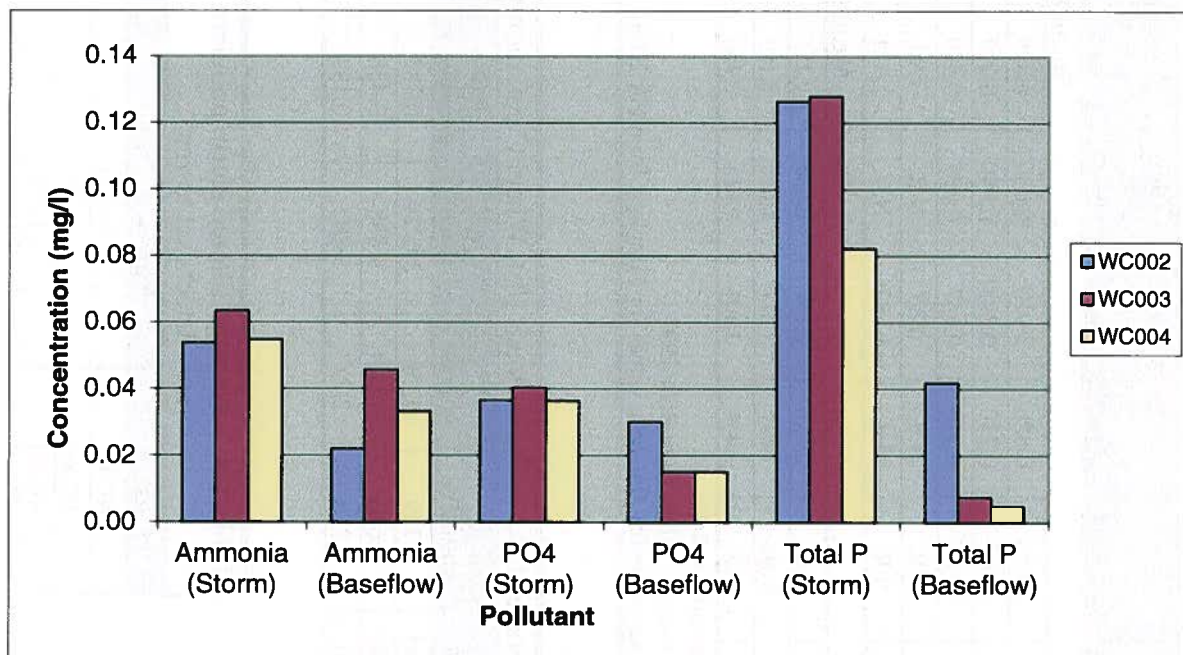


Figure 4-2. Ammonia and phosphorus average storm event mean and baseflow mean concentrations in Wheel Creek, 2013



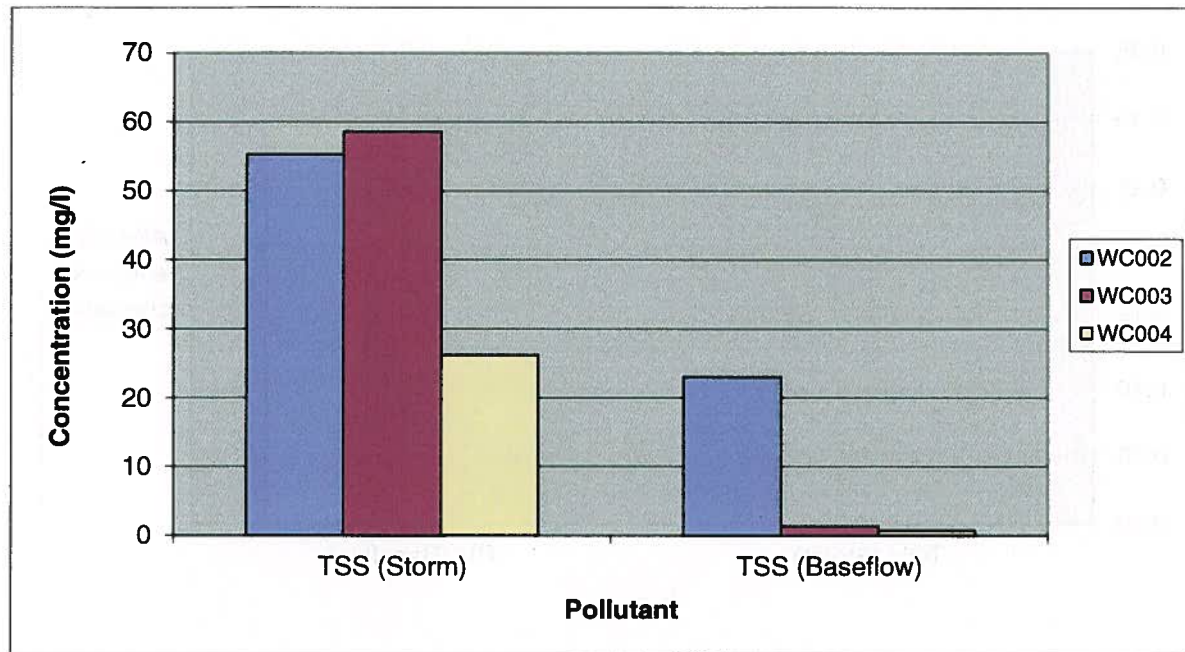


Figure 4-3. TSS average storm event mean and baseflow mean concentrations in Wheel Creek, 2013

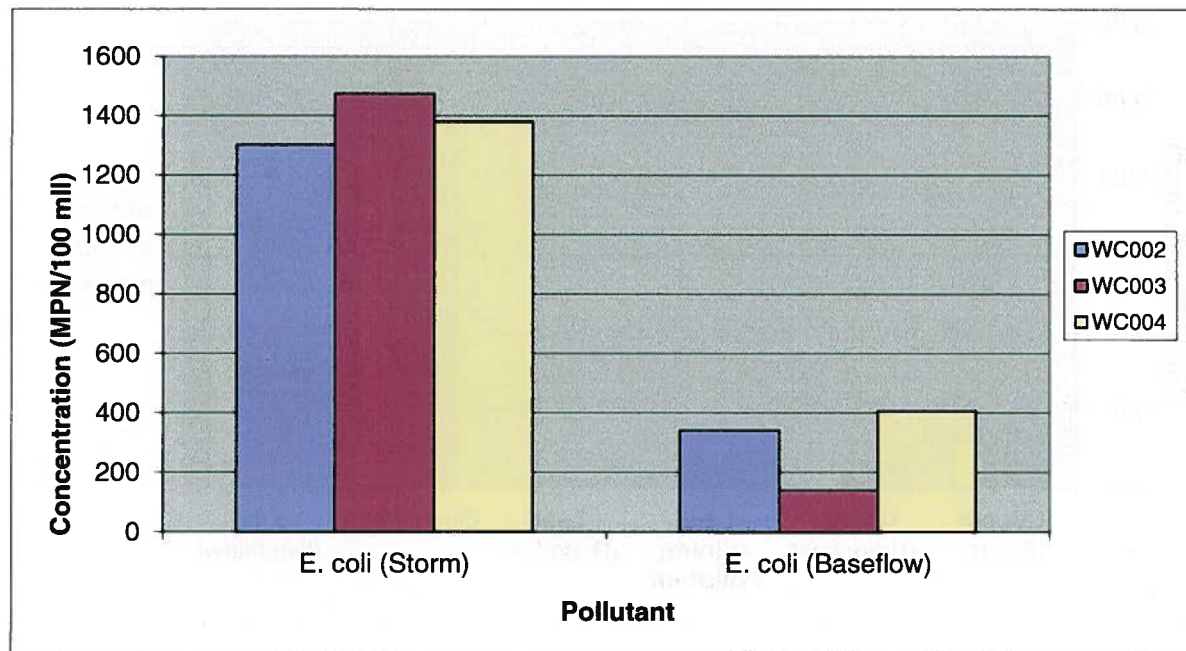


Figure 4-4. *E. coli* average storm and baseflow mean concentrations in Wheel Creek, 2013

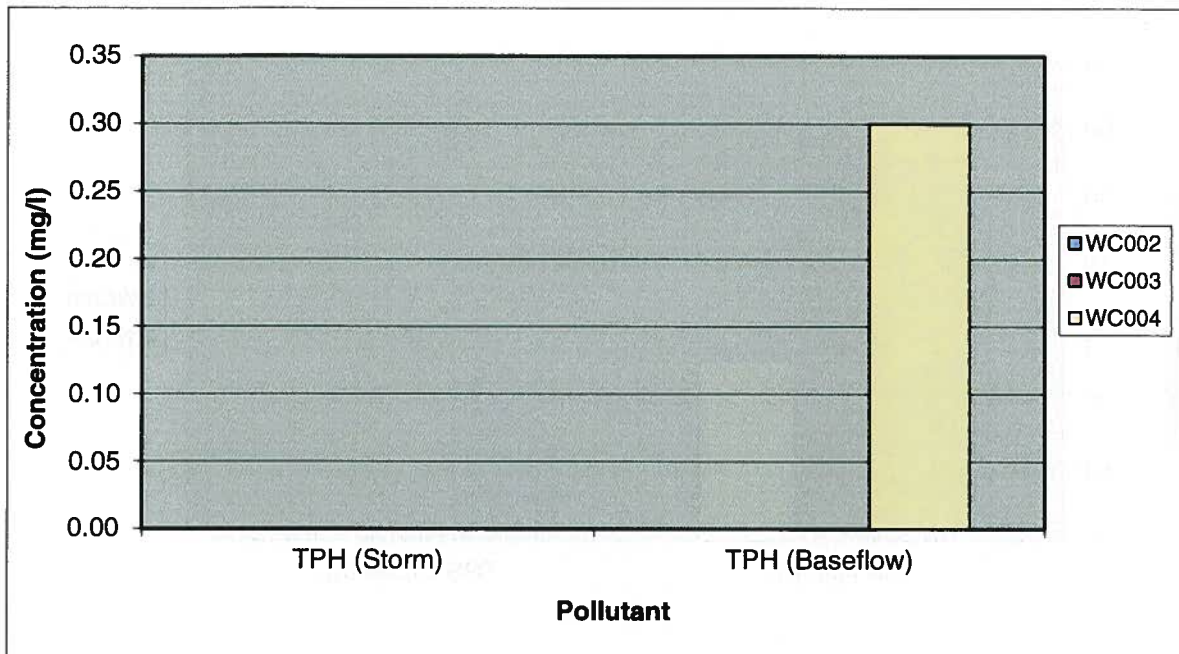


Figure 4-5. TPH average storm and baseflow mean concentrations in Wheel Creek, 2013

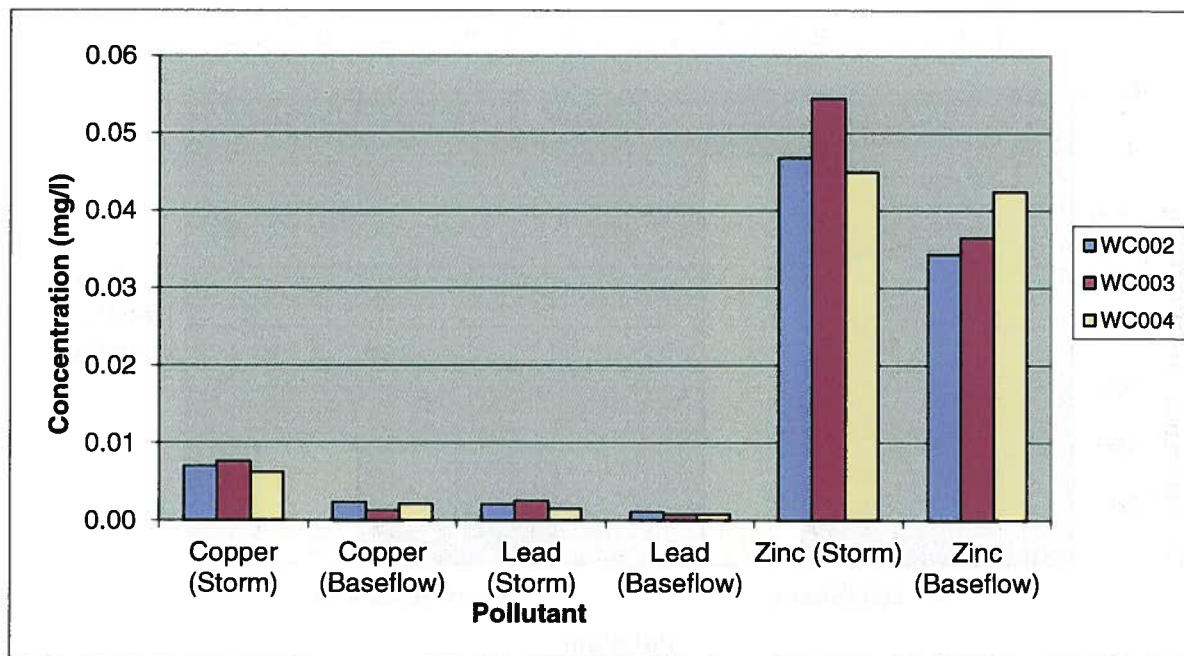
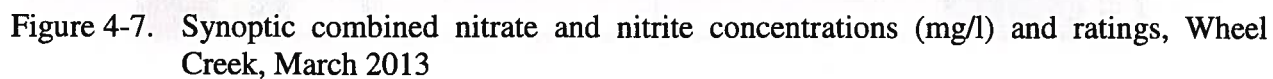


Figure 4-6. Metal average storm event mean and baseflow mean concentrations in Wheel Creek, 2013

Watershed	Station	Catchment size (ha)	Concentration (mg/l)		Discharge (CF/day)	Yield (kg/ha/day)	
			Nitrate/Nitrite	Orthophosphate		Nitrate/Nitrite	Orthophosphate
Wheel Creek	W1	176	1.39	<0.01	48,384	0.0108	<0.000078
	W2	16	0.955	<0.01	2,462	0.0042	<0.000044
	W3	41	1.22	<0.01	449	0.0004	<0.000003
	W4	28	2.02	<0.01	6,401	0.0131	<0.000065
	W5	46	1.69	<0.01	12,455	0.0130	<0.000077
	W6	10	1.82	<0.01	929	0.0048	<0.000026
	W7	15	1.09	<0.01	1,739	0.0036	<0.000033
	W8	17	2.17	<0.01	2,631	0.0095	<0.000044
Reference	R1	209	0.807	0.01	32,296	0.0035	0.000044
	R2	9	0.703	0.01	886	0.0020	0.000028
	R3	16	1.08	0.01	4,959	0.0095	0.000088
	R4	14	2.64	0.02	708	0.0038	0.000029
	R5	127	0.762	0.01	47,813	0.0081	0.000107
	R6	109	0.839	0.01	13,357	0.0029	0.000035
	R7	27	0.957	0.01	2,920	0.0029	0.000031
	R8	29	1.36	0.13	1,380	0.0018	0.000175
Nutrient Level Rating							
Baseline		< 1	< 0.005			< 0.01	< 0.0005
Moderate		1 to 3	0.005 to 0.01			0.01 to 0.02	0.0005 to 0.001
High		3 to 5	0.01 to 0.015			0.02 to 0.03	0.001 to 0.002
Excessive		> 5	> 0.015			> 0.03	> 0.002







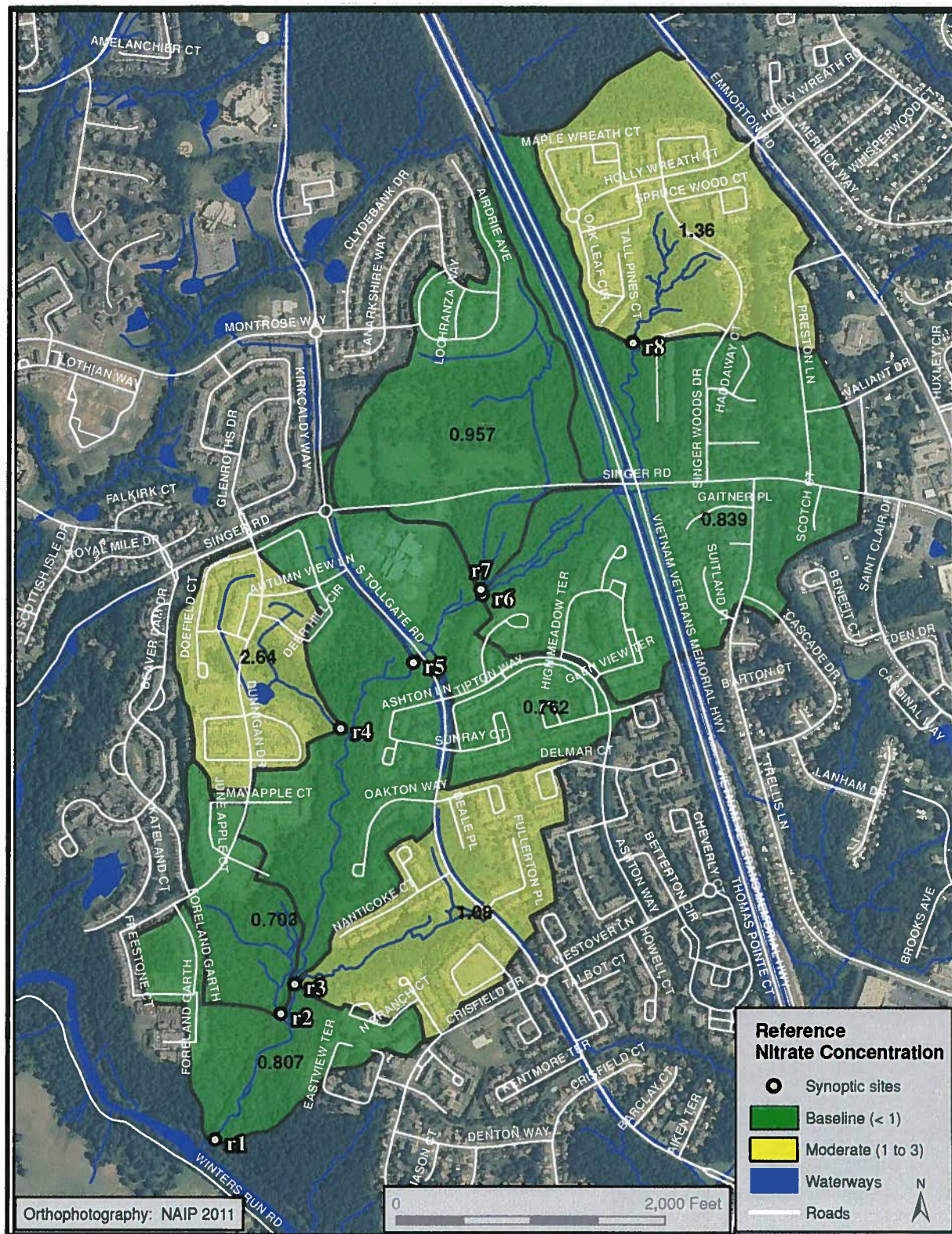


Figure 4-8. Synoptic combined nitrate and nitrite concentrations (mg/l) and ratings, Reference watershed, March 2013



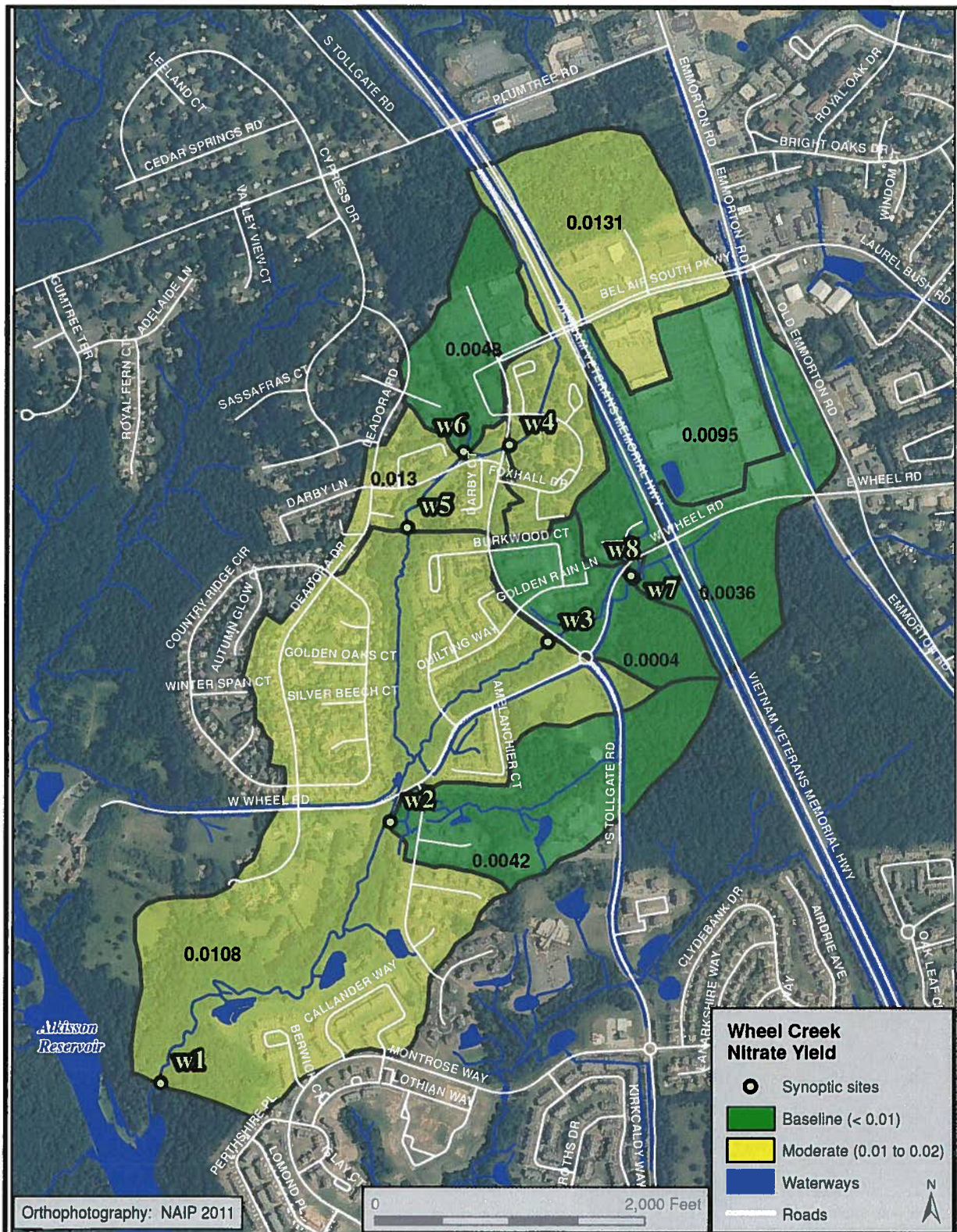
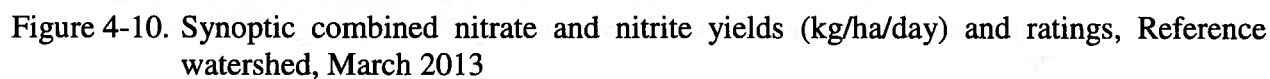
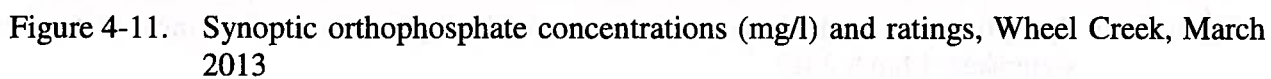


Figure 4-9. Synoptic combined nitrate and nitrite yields (kg/ha/day) and ratings, Wheel Creek, March 2013

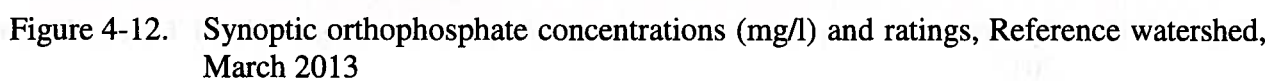




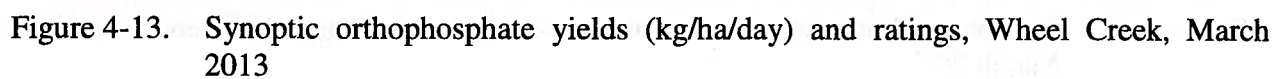














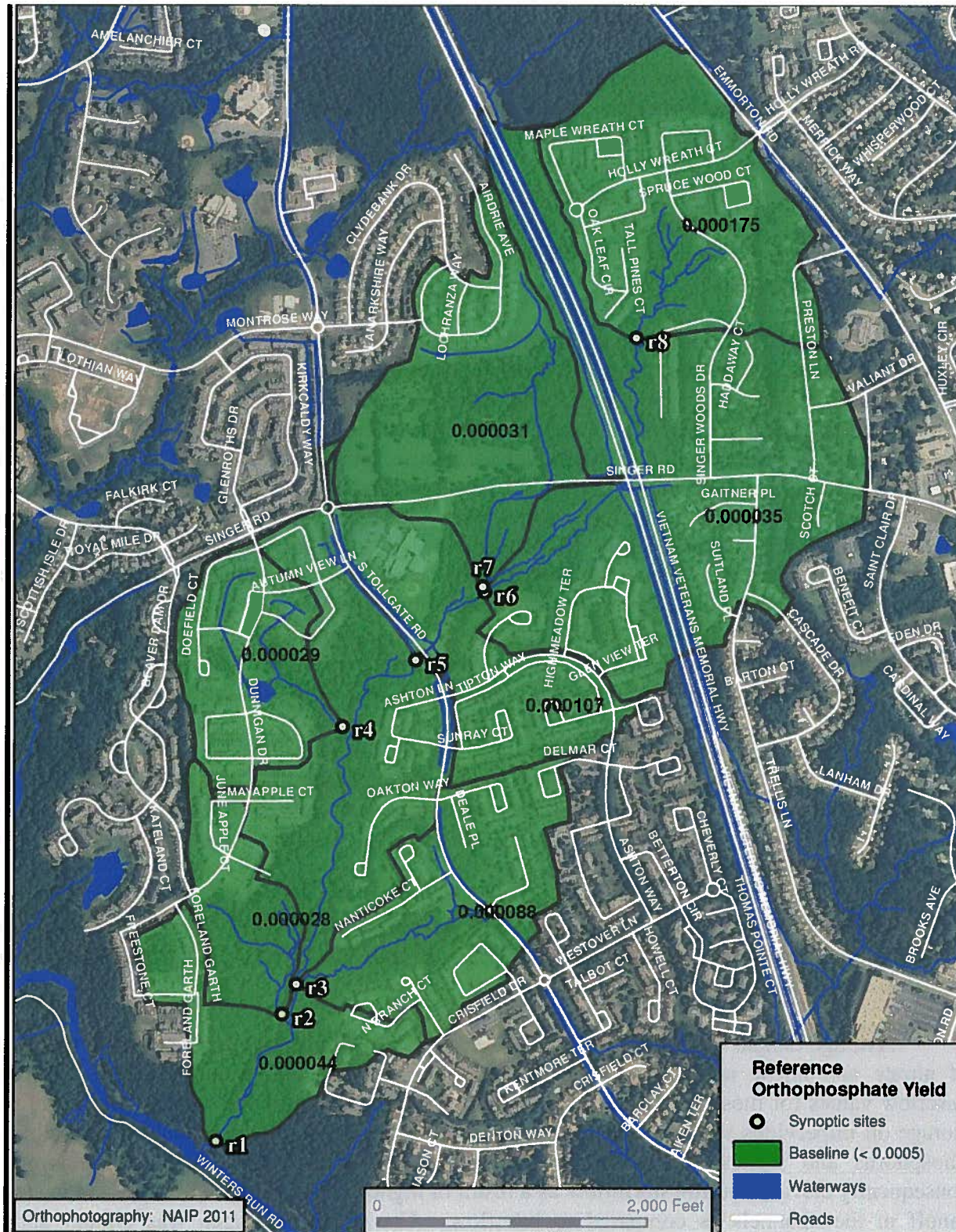


Figure 4-14. Synoptic orthophosphate yields (kg/ha/day) and ratings, Reference watershed, March 2013



## 5.0 CONCLUSIONS

In a cooperative effort, Harford County DPW, Versar, and Maryland DNR conducted water chemistry and long-term flow monitoring in Wheel Creek Watershed. During 2013, the effort encompassed monthly baseflow sampling, ten stormflow sampling events, and synoptic sampling within Wheel Creek Watershed. Baseflow and stormflow monitoring consisted of sampling for suspended solids, copper, lead, zinc, BOD, ammonia, nitrate and nitrite, orthophosphate, total phosphorous, TKN, TPH, and *E. coli*. Synoptic sampling consisted of monitoring for nitrate and nitrite and orthophosphate only in both the Wheel Creek Watershed and a reference watershed.

Established Federal and State reference values for certain pollutants were exceeded on several occasions during monitoring in Wheel Creek, confirming stream chemistry impacts from development. Total nitrogen storm and baseflow results were greater than the EPA recommended reference value of 0.69 mg/l in 99% and 100% of the storm and baseflow samples, respectively. Total phosphorus, when detected, was greater than the EPA recommended reference value of 0.03656 mg/l in 85% of stormflow samples and 3.3% of baseflow samples. All baseflow concentrations for metals were below the MDE surface water criteria while zinc concentrations were greater than the MDE value in 10% of storm samples. In particular, the mean concentration of zinc, which is a component of used motor oil and worn tires, was found to be highest at Station WC004 during baseflow conditions in 2013, which may be a result of the station's close proximity to Route 24 and Festival Shopping Center. In contrast, copper concentrations, resulting from sources such as brake lining wear, were more evenly distributed throughout the study area, however slightly higher at WC003 during stormflow.

*E. coli* bacteria were present in all baseflow and all stormflow samples at all stations. The annual baseflow mean concentration was highest at Station WC004 (406 MPN/100 ml), indicating that bacteria were concentrated upstream. *E. coli* storm EMCs, however, were highest at Station WC003 (1474 MPN/100 ml), showing that bacteria were being transported downstream during storms.

TPH was not detected during any 2013 storms at all stations. Baseflow TPH mean concentration values were below detection limits at Stations WC002 and WC003, but were higher (0.3 mg/l) upstream at Station WC004.

Average annual stormflow EMCs exceeded baseflow concentrations except in the cases of nitrate and nitrite and TPH at specific stations. Storm EMC values exceeded average baseflow values for most parameters at all stations as a result of mobilization of pollutants from storage on impervious surfaces and in the sediment layer of the stream channel during storms. Phosphorus and metals bind to particulate matter and their average concentrations were consequently elevated during stormflow as a result of higher TSS concentrations present in storm runoff in the channels as compared to baseflow. Conversely, nitrogen was diluted during stormflow, resulting in storm EMC values that were lower than baseflow mean concentration values at all monitoring stations.

For many parameters, stormflow EMC values were much higher than corresponding average baseflow concentration values at each station. For example, the storm EMC values for TKN ranged from 3.2 to 4.0 times the baseflow concentration values. In the case of phosphorus, stormflow produced EMC values that were 3 to 18.3 times the average baseflow value. Stormflow EMC values for copper were 3.5 to 8 times the baseflow concentration values, however, average zinc stormflow concentrations were between 1 and 1.5 times the average baseflow concentrations.

Average stormflow loads for all parameters were highest at Station WC002 and lowest at Station WC004. Pollutant loading is a function of concentration and discharge; therefore, the highest loads were calculated at the downstream station (Station WC002) at which the highest discharges were recorded during storms. The average TSS load at Station WC002 was 1,983 pounds, which is over thirteen times the average load at Station WC004. The average delivery of nitrate and nitrite was over 29 pounds at Station WC002 during 2013 whereas transport at Station WC004 was only 3.8 pounds. Loads for other parameters such as TKN, and total phosphorus were on the order of 10 times higher at Station WC002 than at Station WC004 during an average storm.

Nitrate and nitrite concentrations in samples taken during synoptic sampling in Wheel Creek fell into the moderate category with the exception of station W2, which was baseline. Nitrogen yields at stations W1, W4, and W5 were in the moderate category, with W4 being the highest, while all other stations were categorized as baseline. All orthophosphorus concentrations during synoptic sampling in Wheel Creek were below detection limits. Reference nitrate and nitrite concentrations fell into the baseline category at five of eight stations and moderate in the remainder. Reference nitrate and nitrite yields were all in the baseline category. Unlike Wheel Creek Watershed, reference orthophosphorus concentrations were all above detection limits with two stations (R4 and R8) categorized as excessive. All other concentrations fell into the moderate category. Orthophosphorus yields were categorized as baseline in both the Wheel Creek and the Reference Watersheds.

The results of 2013 monitoring indicate that conditions in the headwaters of Wheel Creek are causing elevated levels of pollutants to be detected at Station WC004. The pollutants that were present at higher concentrations at Station WC004 than at other stations during monthly baseflow sampling included total nitrogen, zinc, *E. coli*, and TPH. Stormflow caused average concentrations to elevate at all stations from baseflow concentrations for all parameters save combined nitrate and nitrite and TPH, thereby masking otherwise comparatively higher concentrations of the above pollutants noted at Station WC004. Maximum EMCs were found at Station WC003, when compared to other stations, for BOD, ammonia, orthophosphate, total phosphorous, TSS, copper, zinc, and *E. coli* during storm monitoring. Higher concentrations of these pollutants at Station WC003 during stormflow, relative to Station WC002 and Station WC004, indicate that water quality at that station was adversely affected by possible high pollutant concentration sources along nearby Wheel Road or north from Maryland Route 24.



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## 6.0 REFERENCES

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# **APPENDIX A**

## **STORM EVENT SUMMARY REPORTS**





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**WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING**  
**SUMMARY REPORT**  
*FEBRUARY 26, 2013*

## **INTRODUCTION**

On February 26, 2013, Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

## **RESULTS**

Versar field staff traveled to the site on February 26 to program the Sigma automated samplers to sample the event. Rainfall initiated at approximately 5:00 p.m. on February 26. At the Darby Lane Weather Underground Station, 0.72 inches of rain was recorded.

On February 26, shortly after initial storm flow, field staff took grab water samples to be tested for TPH and *E. coli* at all three stations. Arrangements were made to meet with laboratory personnel at the Providence Road Park and Ride and the *E. coli* samples were handed over for analysis.

Field staff traveled to the station on February 27 to composite automated samples. During compositing, field staff noted that WC002 area velocity probe malfunctioned during the last portion of the event from reasons unknown. Wedges used to composite the falling limb correspond with those used for WC004. Composite samples, including TPH, were transported to the County office building for pickup by the laboratory.

Hydrographs for the February 26 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the February 26 storm are shown in Table 1 through Table 4.

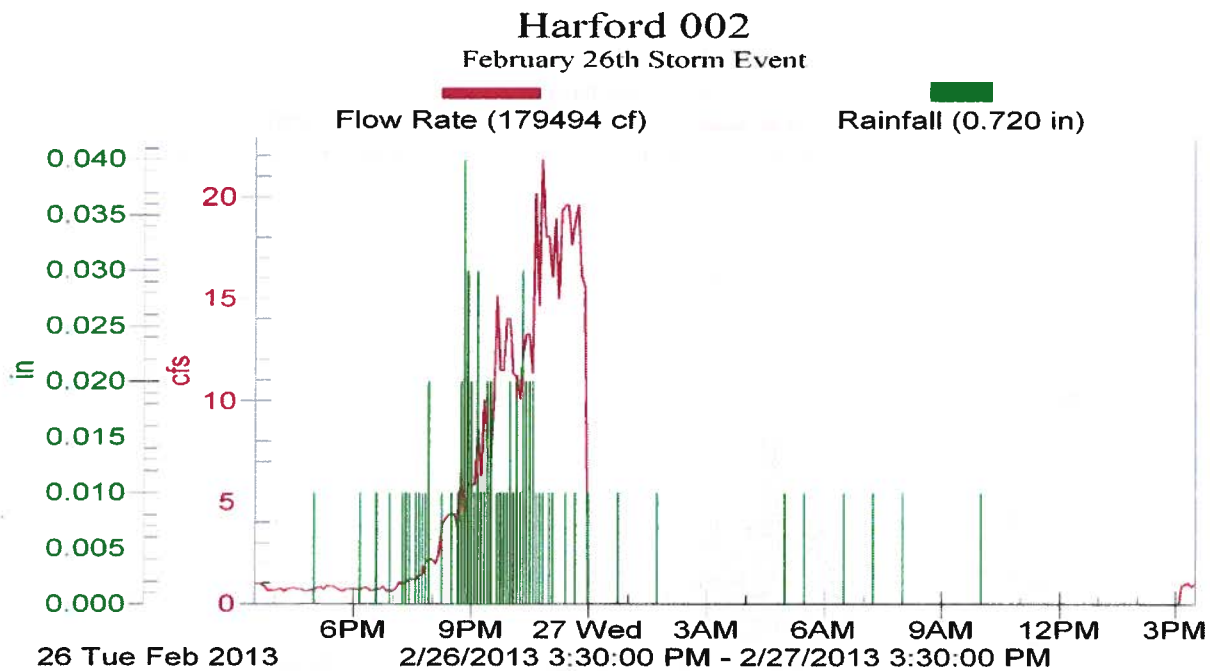


Figure 1. Hydrograph at Station WC002 for February 26, 2013 storm. Rainfall data source: Darby Lane Weather Underground Station.

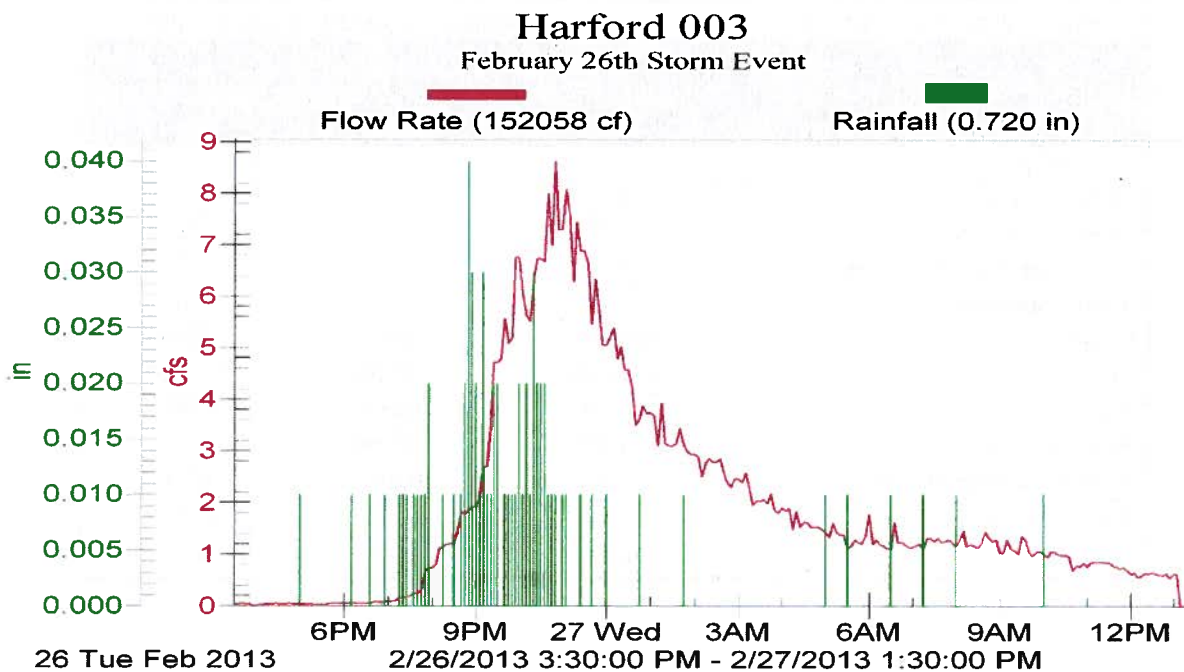


Figure 2. Hydrograph at Station WC003 for February 26, 2013 storm. Rainfall data source: Darby Lane Weather Underground Station.

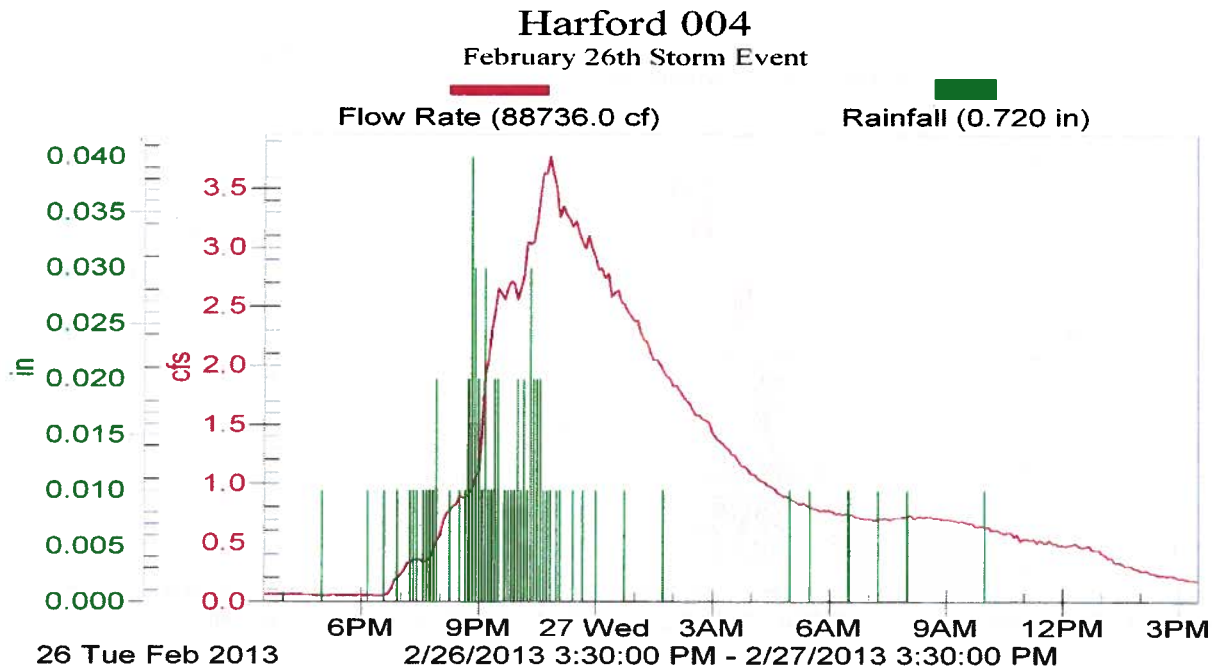


Figure 3. Hydrograph at Station WC004 for February 26, 2013 storm. Rainfall data source: Darby Lane Weather Underground Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	February 26, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	< 2	3	5
Nitrate Nitrogen	2.43	1.87	1.02
Nitrate-Nitrite Nitrogen	2.43	1.87	1.02
Orthophosphate Phosphorus	0.01	0.02	0.03
Solids (Suspended)	13.4	61	30
Copper	0.00180	0.00630	0.0155
Lead	< 0.0004	0.00160	0.00290
Zinc	0.0291	0.0602	0.0825
Ammonia Nitrogen	< 0.099	< 0.099	0.111
Kjeldahl Nitrogen (Total)	< 0.1	0.518	0.933
Total Phosphorus	< 0.1	0.0752	0.0939
pH	6.68	6.89	6.75

Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb			
Constituent	February 26, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	< 2	< 2	< 2
Nitrate Nitrogen	0.659	0.544	0.435
Nitrate-Nitrite Nitrogen	0.659	0.544	0.435
Orthophosphate Phosphorus	0.03	0.05	0.03
Solids (Suspended)	85.2	82.3	24.6
Copper	0.0089	0.0097	0.0065
Lead	0.0028	0.0031	0.0015
Zinc	0.0517	0.0578	0.0486
Ammonia Nitrogen	< 0.099	0.0523	< 0.099
Kjeldahl Nitrogen (Total)	0.728	0.759	0.327
Total Phosphorus	0.14	0.129	0.0635
pH	7.05	7.20	7.04

Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb			
Constituent	February 26, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	< 2	3	< 2
Nitrate Nitrogen	0.649	0.626	0.532
Nitrate-Nitrite Nitrogen	0.649	0.626	0.532
Orthophosphate Phosphorus	0.03	0.02	0.01
Solids (Suspended)	35	16	5.4
Copper	0.0046	0.0041	0.0025
Lead	0.0013	0.00087	< 0.0004
Zinc	0.033	0.0335	0.0266
Ammonia Nitrogen	< 0.099	< 0.099	< 0.099
Kjeldahl Nitrogen (Total)	0.55	0.407	0.327
Total Phosphorus	0.0966	0.0419	0.0283
pH	6.72	7.05	6.78

Table 4. Analytical Results – Wheel Creek Grab Sampling			
Constituent	Station WC002	Station WC003	Station WC004
February 26, 2013 (rising)			
TPH (mg/L)	< 1.89	< 1.89	< 1.89
<i>E. coli</i> (MPN/100 ml)	45.7	27.2	22.3
Temp (C)	6.03	5.99	7.68
DO (mg/L)	13.5	13.8	11.9
pH	6.68	6.50	6.18
Sp. Cond. (mS/cm <sup>2</sup> )	0.652	0.917	1.27



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**WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING**  
**SUMMARY REPORT**  
*MARCH 12, 2013 STORM*

## **INTRODUCTION**

On March 12, 2013 Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

## **RESULTS**

Versar field staff traveled to the site on March 11 to pre-program the Sigma automated samplers to sample the event. Rainfall initiated at approximately 1:45 a.m. on March 12. At the Darby Lane Weather Underground Station, 0.92 inches of rain was recorded.

Field staff traveled to the station on March 13 to composite automated samples. The composite samples were transported to the County office building for pickup by the laboratory. No grab sample data are available as the samplers were pre-programmed to start between the hours of 12:00 a.m. and 6:00 a.m.

Hydrographs for the March 12 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the March 12 storm are shown in Table 1 through Table 3.

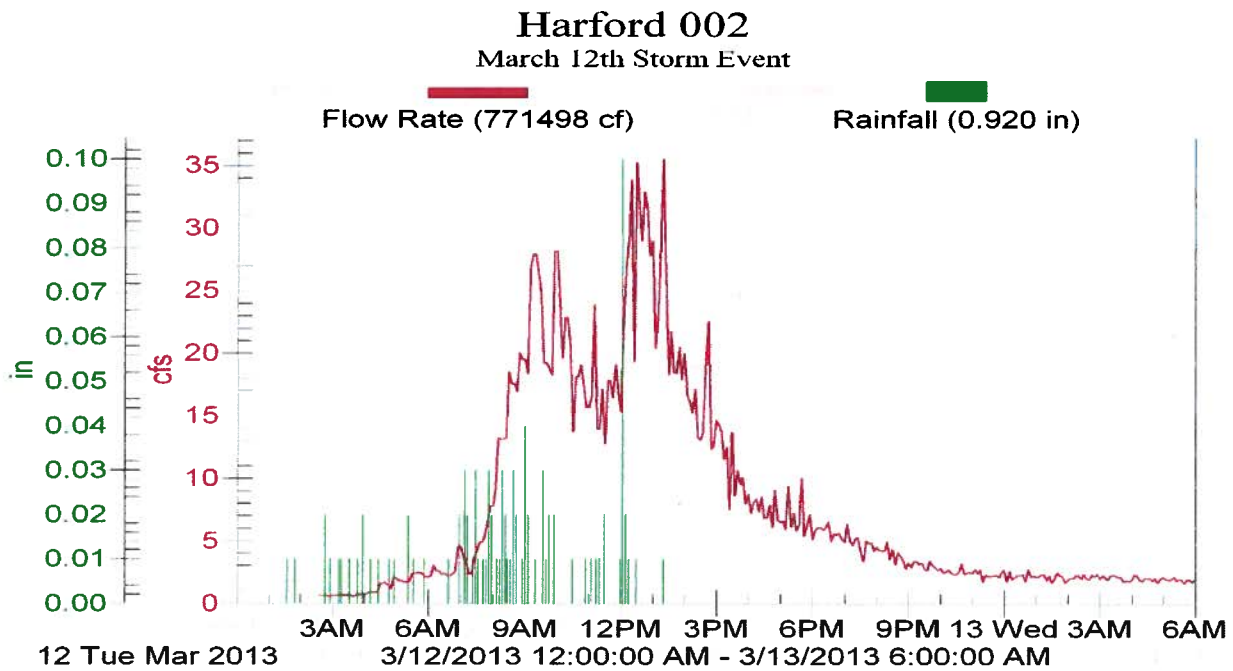


Figure 1. Hydrograph at Station WC002 for March 12, 2013 storm. Rainfall data source: Darby Lane Weather Underground Station.

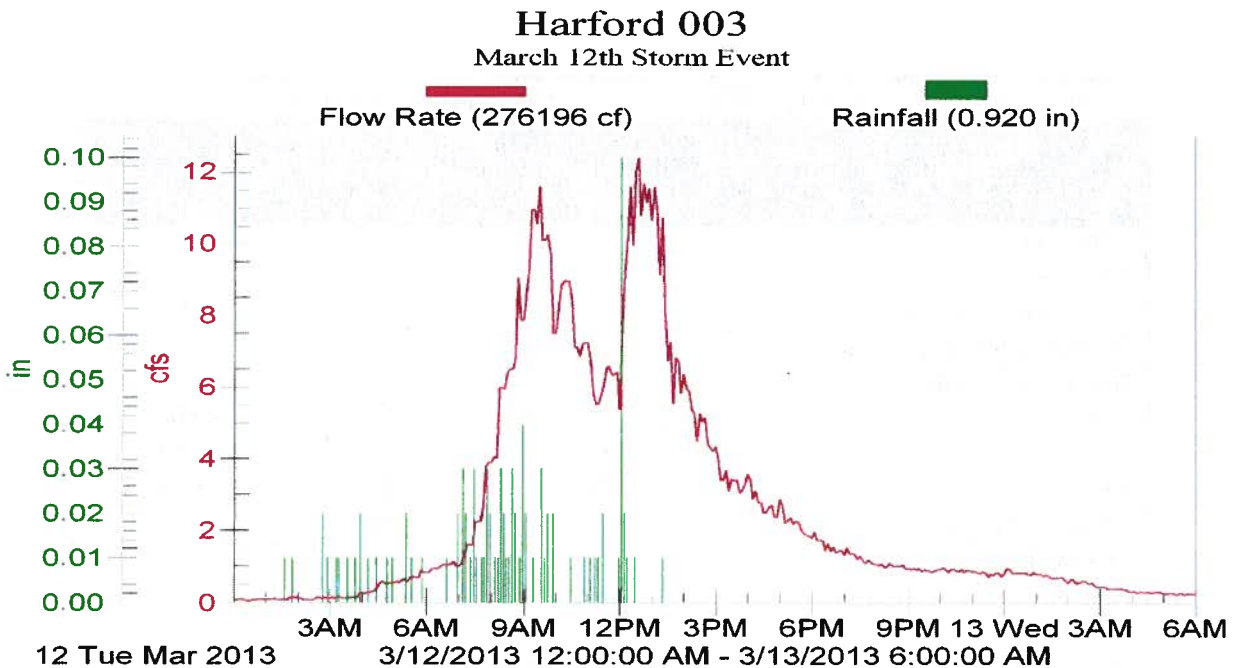


Figure 2. Hydrograph at Station WC003 for March 12, 2013 storm. Rainfall data source: Darby Lane Weather Underground Station.

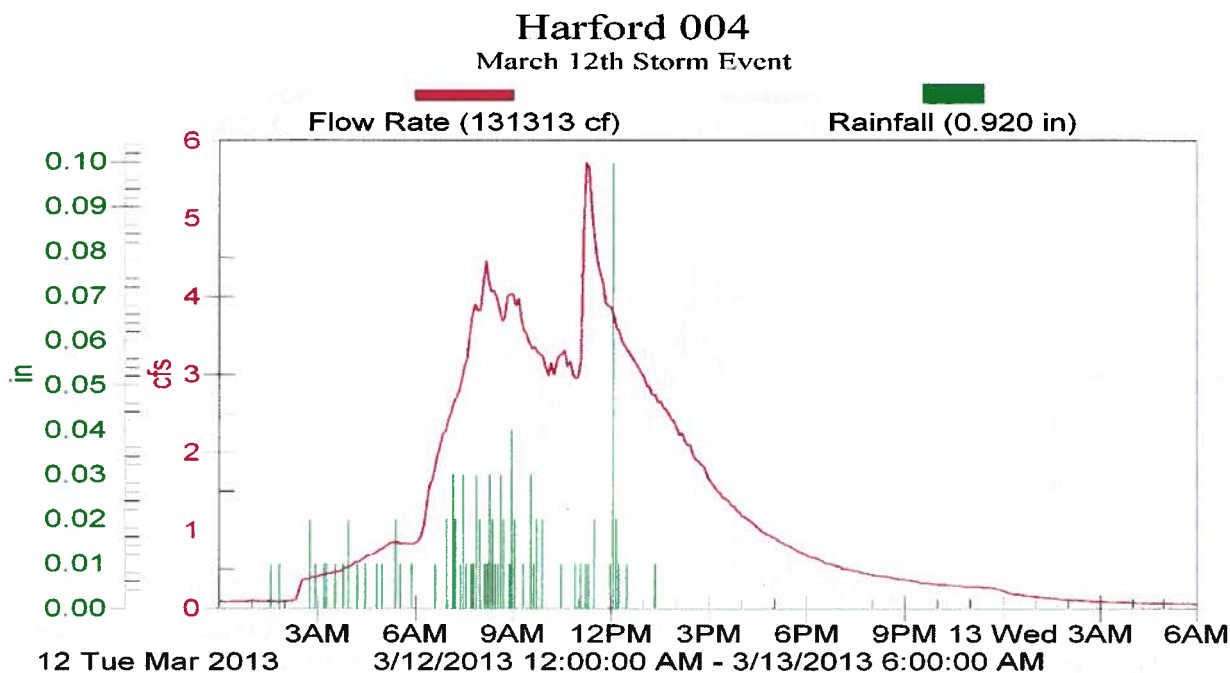


Figure 3. Hydrograph at Station WC004 for March 12, 2013 storm. Rainfall data source: Darby Lane Weather Underground Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	March 12, 2013		
	Station WC002 (mg/L.)	Station WC003 (mg/L.)	Station WC004 (mg/L.)
5-Day BOD	3	2	3
Nitrate Nitrogen	1.52	1.2	0.782
Nitrate-Nitrite Nitrogen	1.52	1.2	0.782
Orthophosphate Phosphorus	< 0.01	0.01	0.02
Solids (Suspended)	17	30.4	66.4
Copper	0.004	0.0045	0.0083
Lead	0.00064	0.00091	0.0023
Zinc	0.0319	0.0308	0.061
Ammonia Nitrogen	0.0517	0.0603	0.118
Kjeldahl Nitrogen (Total)	0.417	0.41	0.721
Total Phosphorus	0.0472	0.0496	0.102
pH	6.52	6.67	6.81

Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb			
Constituent	March 12, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	5	4	< 2
Nitrate Nitrogen	0.559	0.604	0.488
Nitrate-Nitrite Nitrogen	0.559	0.604	0.488
Orthophosphate Phosphorus	0.04	0.06	0.05
Solids (Suspended)	175	188	41.2
Copper	0.0129	0.0158	0.0064
Lead	0.0049	0.0058	0.002
Zinc	0.0735	0.0816	0.0432
Ammonia Nitrogen	0.089	0.0616	< 0.099
Kjeldahl Nitrogen (Total)	1.11	1.1	0.398
Total Phosphorus	0.246	0.259	0.0768
pH	6.65	6.83	6.91

Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb			
Constituent	March 12, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	2	< 2	< 2
Nitrate Nitrogen	1.68	1.49	2.24
Nitrate-Nitrite Nitrogen	1.68	1.49	2.24
Orthophosphate Phosphorus	0.01	0.01	0.01
Solids (Suspended)	5.6	< 5	< 5
Copper	0.0018	0.0026	0.0022
Lead	< 0.0004	< 0.0004	< 0.0004
Zinc	0.031	0.034	0.036
Ammonia Nitrogen	< 0.099	< 0.099	0.0694
Kjeldahl Nitrogen (Total)	0.283	< 0.1	< 0.1
Total Phosphorus	0.0245	< 0.01	< 0.01
pH	6.41	6.53	6.43



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## **WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING**

### **SUMMARY REPORT**

*MAY 7, 2013 STORM*

#### **INTRODUCTION**

On May 7, 2013, Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

#### **RESULTS**

Versar field staff traveled to the site on May 7 to program the Sigma automated samplers to sample the event. Rainfall initiated at approximately 11:05 a.m. on May 7. At the Darby Lane Weather Underground Station, 0.49 inches of rain was recorded.

On May 7 shortly after initial storm flow, field staff took grab water samples to be tested for TPH and *E. coli* at all three stations. Arrangements were made to meet with laboratory personnel at the Providence Road Park and Ride and *E. coli* samples were handed over for analysis.

Field staff traveled to the station on May 8 to composite automated samples. During compositing, field staff noted that the area velocity probe at WC002 malfunctioned during the event from unknown causes. Wedges used to composite samples at WC002 correspond to those used for WC004. Composite samples, including TPH, were transported to the County office building for pickup by the laboratory.

Hydrographs for the May 8 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the May 8 storm are shown in Table 1 through Table 4.

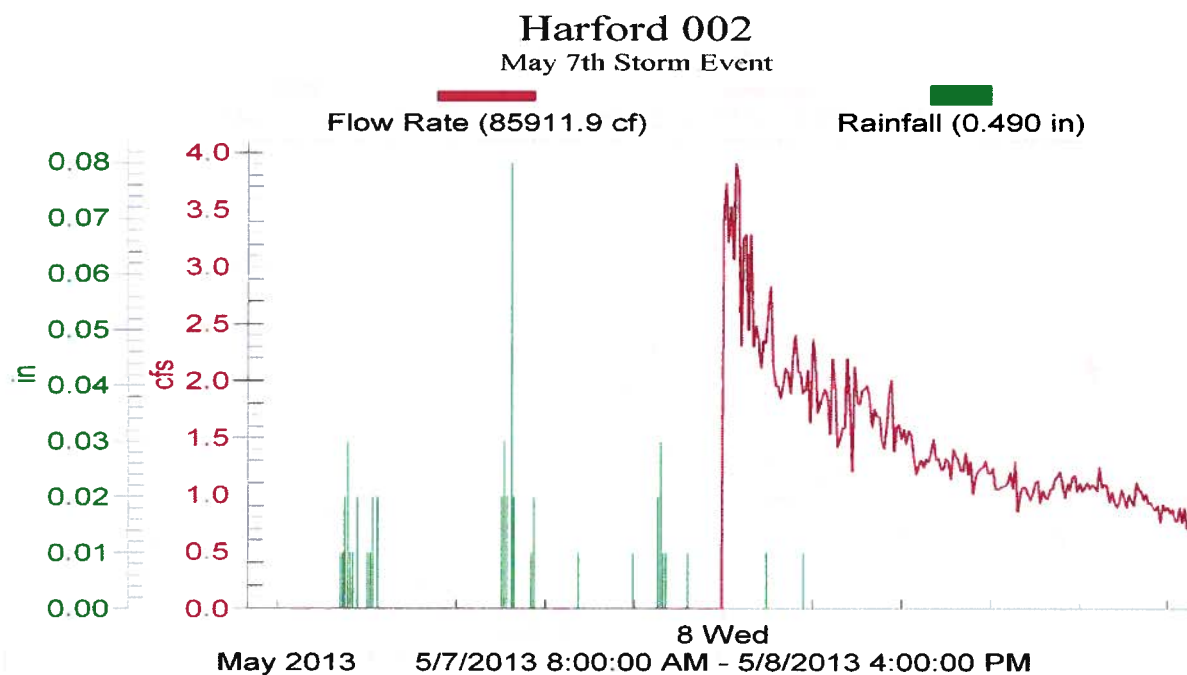


Figure 1. Hydrograph at Station WC002 for May 7, 2013 storm. Rainfall data source: Darby Lane Weather Underground Station.

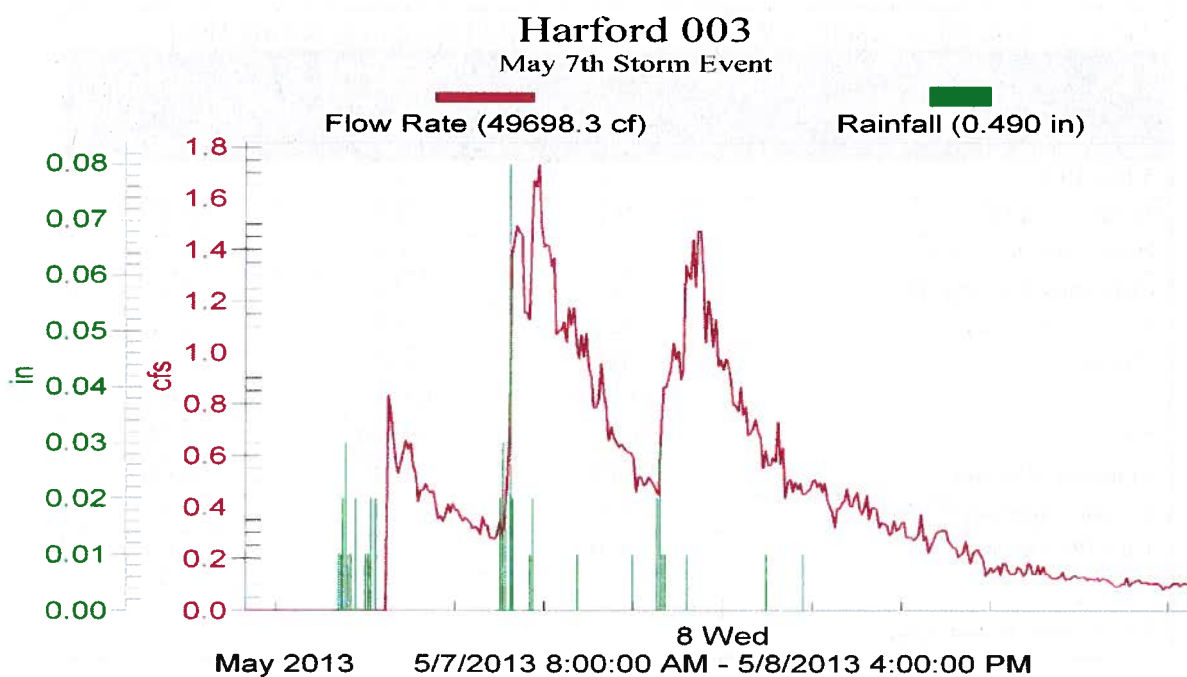


Figure 2. Hydrograph at Station WC003 for May 7, 2013 storm. Rainfall data source: Darby Lane Weather Underground Station.

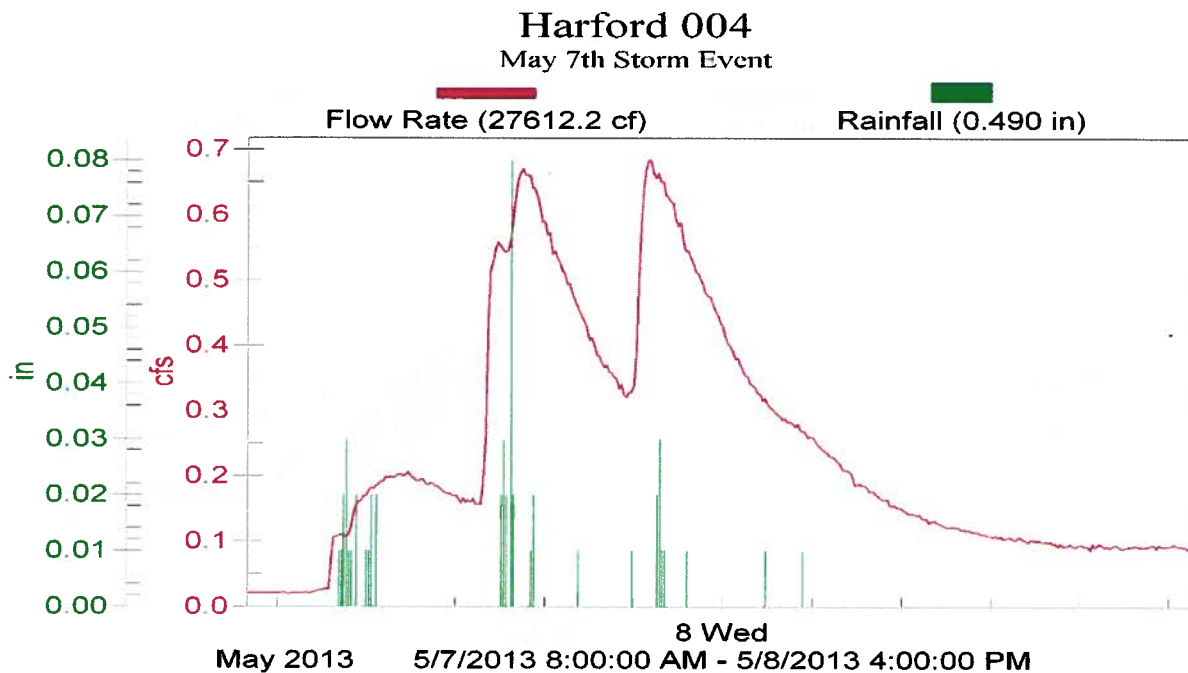


Figure 3. Hydrograph at Station WC004 for May 7, 2013 storm. Rainfall data source: Darby Lane Weather Underground Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	May 7, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	3	< 2	5
Nitrate Nitrogen	N.T.	N.T.	N.T.
Nitrate-Nitrite Nitrogen	1.3	1.52	1.24
Orthophosphate Phosphorus	< 0.01	< 0.01	0.03
Solids (Suspended)	< 5	8.5	82.8
Copper	0.0035	0.0061	0.0168
Lead	0.00035	0.00044	0.003
Zinc	0.0223	0.0368	0.0755
Ammonia Nitrogen	0.106	0.122	0.141
Kjeldahl Nitrogen (Total)	0.59	1.24	1.18
Total Phosphorus	< 0.01	0.0375	0.176
pH	7.42	7.61	7.48
N.T. = Analyte Not Tested			

Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb			
Constituent	May 7, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	5	2	2
Nitrate Nitrogen	N.T.	N.T.	N.T.
Nitrate-Nitrite Nitrogen	22.7	0.902	0.74
Orthophosphate Phosphorus	< 0.01	< 0.01	0.05
Solids (Suspended)	12.5	18	25.5
Copper	0.0075	0.0065	0.0091
Lead	0.00043	0.00067	0.0012
Zinc	0.0273	0.0323	0.0452
Ammonia Nitrogen	0.147	0.147	0.139
Kjeldahl Nitrogen (Total)	2.14	0.734	0.687
Total Phosphorus	0.0714	0.0651	0.116
pH	7.31	7.50	7.33
N.T. = Analyte Not Tested			

Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb			
Constituent	May 7, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	4	< 2	2
Nitrate Nitrogen	N.T.	N.T.	N.T.
Nitrate-Nitrite Nitrogen	0.867	0.913	0.716
Orthophosphate Phosphorus	0.02	< 0.01	< 0.01
Solids (Suspended)	31.5	12.5	7.8
Copper	0.0077	0.0059	0.0077
Lead	0.00072	0.00061	0.00057
Zinc	0.0325	0.031	0.0394
Ammonia Nitrogen	0.0965	0.137	0.137
Kjeldahl Nitrogen (Total)	1.17	0.542	0.501
Total Phosphorus	0.0729	0.0454	0.0438
pH	7.40	7.44	7.15
N.T. = Analyte Not Tested			

Table 4. Analytical Results – Wheel Creek Grab Sampling			
Constituent	Station WC002	Station WC003	Station WC004
May 7, 2013 (rising)			
TPH (mg/L)	< 1.89	< 1.89	< 1.89
<i>E. coli</i> (MPN/100 ml)	2420	1550	1120
Temp (C)	14.4	14.74	15.43
DO (mg/L)	9.94	9.77	7.49
pH	7.45	7.31	7.47
Sp. Cond. (mS/cm <sup>2</sup> )	0.537	0.647	0.533



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## **WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING**

### **SUMMARY REPORT**

*JUNE 13, 2013*

#### **INTRODUCTION**

On June 13, 2013, Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

#### **RESULTS**

Versar field staff traveled to the site on June 13 to program the Sigma automated samplers to sample the event. Rainfall initiated at approximately 7:55 a.m. on June 13. At the Wheel Creek Rain Gauge Station, 0.63 inches of rain were recorded.

On June 13 shortly after initial storm flow, field staff took grab water samples to be tested for TPH and *E. coli* at all three stations. Arrangements were made to meet with laboratory personnel at the Providence Road Park and Ride and *E. coli* samples were handed over for analysis.

Field staff traveled to the station on June 14 to composite automated samples. Composite samples, including TPH, were transported to the County office building for pickup by the laboratory.

Hydrographs for the June 13 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the June 13 storm are shown in Table 1 through Table 4.

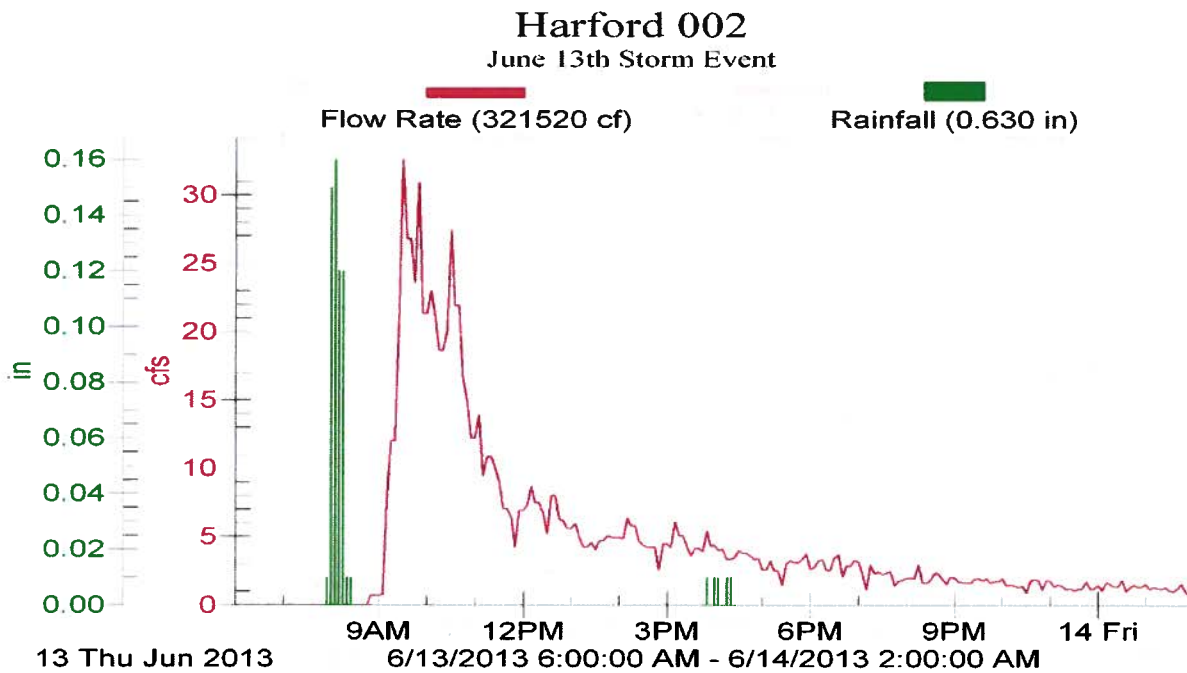


Figure 1. Hydrograph at Station WC002 for June 13, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

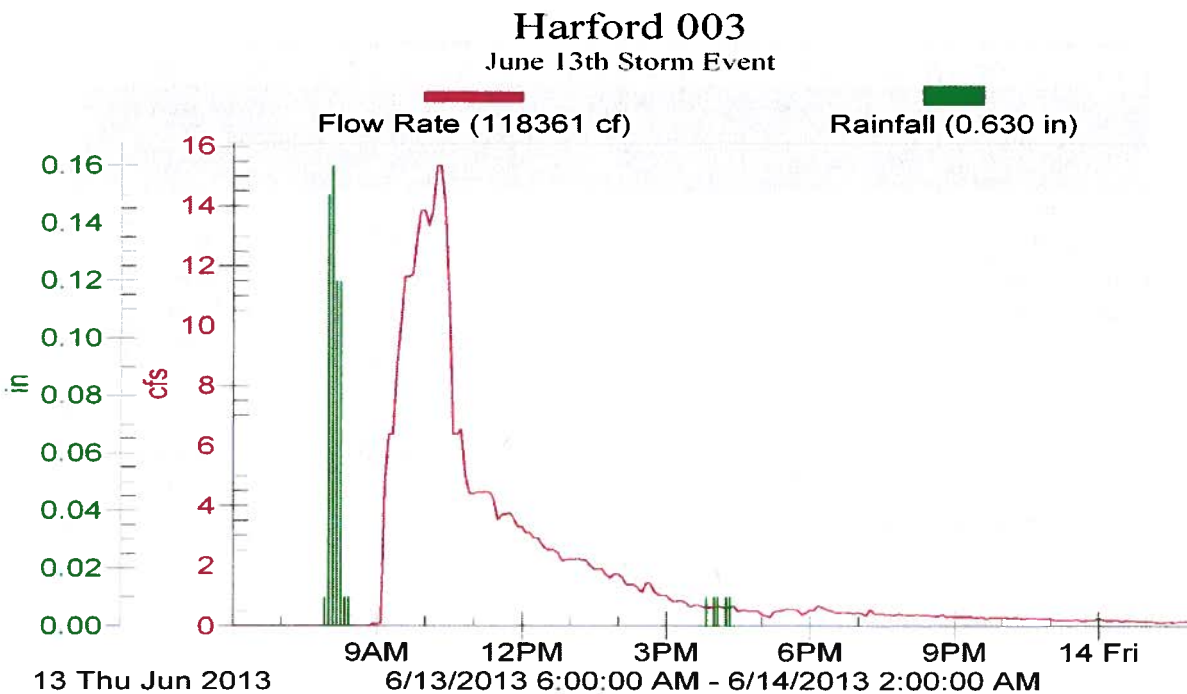


Figure 2. Hydrograph at Station WC003 for June 13, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

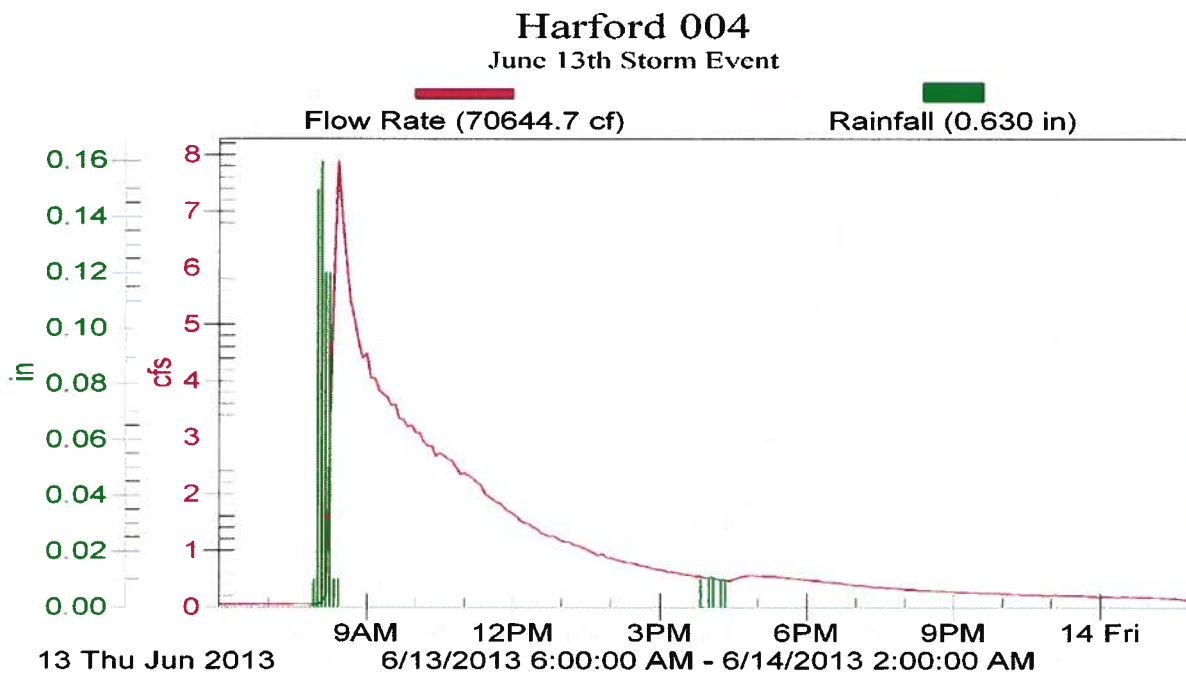


Figure 3. Hydrograph at Station WC004 for June 13, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	June 13, 2013		
	Station WC002 (mg/L.)	Station WC003 (mg/L.)	Station WC004 (mg/L.)
5-Day BOD	8	13	12
Nitrate Nitrogen	1.35	0.911	0.865
Nitrate-Nitrite Nitrogen	1.35	0.911	0.865
Orthophosphate Phosphorus	0.05	0.06	0.06
Solids (Suspended)	129	211	151
Copper	0.0088	0.0171	0.0163
Lead	0.0031	0.0074	0.0069
Zinc	0.0519	0.0968	0.104
Ammonia Nitrogen	0.182	0.11	0.083
Kjeldahl Nitrogen (Total)	1.2	1.54	2.02
Total Phosphorus	0.218	0.32	0.393
pH	7.22	6.98	7.24



Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb			
Constituent	June 13, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	9	29	7
Nitrate Nitrogen	0.703	0.593	0.571
Nitrate-Nitrite Nitrogen	0.703	0.593	0.571
Orthophosphate Phosphorus	0.06	0.06	0.03
Solids (Suspended)	117	55.5	29.6
Copper	0.0099	0.0034	0.0059
Lead	0.0037	0.00076	0.0016
Zinc	0.0513	0.0266	0.0327
Ammonia Nitrogen	0.135	0.119	0.0502
Kjeldahl Nitrogen (Total)	1.54	0.424	0.875
Total Phosphorus	0.284	0.054	0.104
pH	7.54	7.21	7.53

Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb			
Constituent	June 13, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	6	< 2	< 2
Nitrate Nitrogen	0.737	0.85	0.76
Nitrate-Nitrite Nitrogen	0.737	0.85	0.76
Orthophosphate Phosphorus	0.15	0.02	0.04
Solids (Suspended)	26.5	12.2	7.2
Copper	0.0049	0.008	0.003
Lead	0.0011	0.002	0.00053
Zinc	0.0328	0.0446	0.0287
Ammonia Nitrogen	0.0859	0.0739	0.125
Kjeldahl Nitrogen (Total)	0.582	0.818	0.325
Total Phosphorus	0.0936	0.129	0.0323
pH	7.03	7.15	7.44

Table 4. Analytical Results – Wheel Creek Grab Sampling			
Constituent	Station WC002	Station WC003	Station WC004
June 13, 2013 (rising)			
TPH (mg/L)	< 1.89	< 1.89	< 1.89
<i>E. coli</i> (MPN/100 ml)	> 2420	> 2420	> 2420
Temp (C)	20.1	19.5	18.9
DO (mg/L)	10.6	10.9	9.76
pH	7.37	7.33	7.24
Sp. Cond. (mS/cm <sup>2</sup> )	0.156	0.264	0.360

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**WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING**  
**SUMMARY REPORT**  
*AUGUST 1, 2013*

## **INTRODUCTION**

On August 1, 2013, Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

## **RESULTS**

Versar field staff traveled to the site on July 31 to pre-program the Sigma automated samplers to sample the event. Rainfall initiated at approximately 2:50 a.m. on August 1. At the Wheel Creek Rain Gauge Station, 0.76 inches of rain was recorded.

Field staff traveled to the station on August 2 to composite automated samples. Composite samples were transported to the County office building for pickup by the laboratory. No grab sample data are available as the samplers were pre-programmed to start between the hours of 12:00 a.m. and 6:00 a.m.

Hydrographs for the August 1 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the August 1 storm are shown in Table 1 through Table 3.

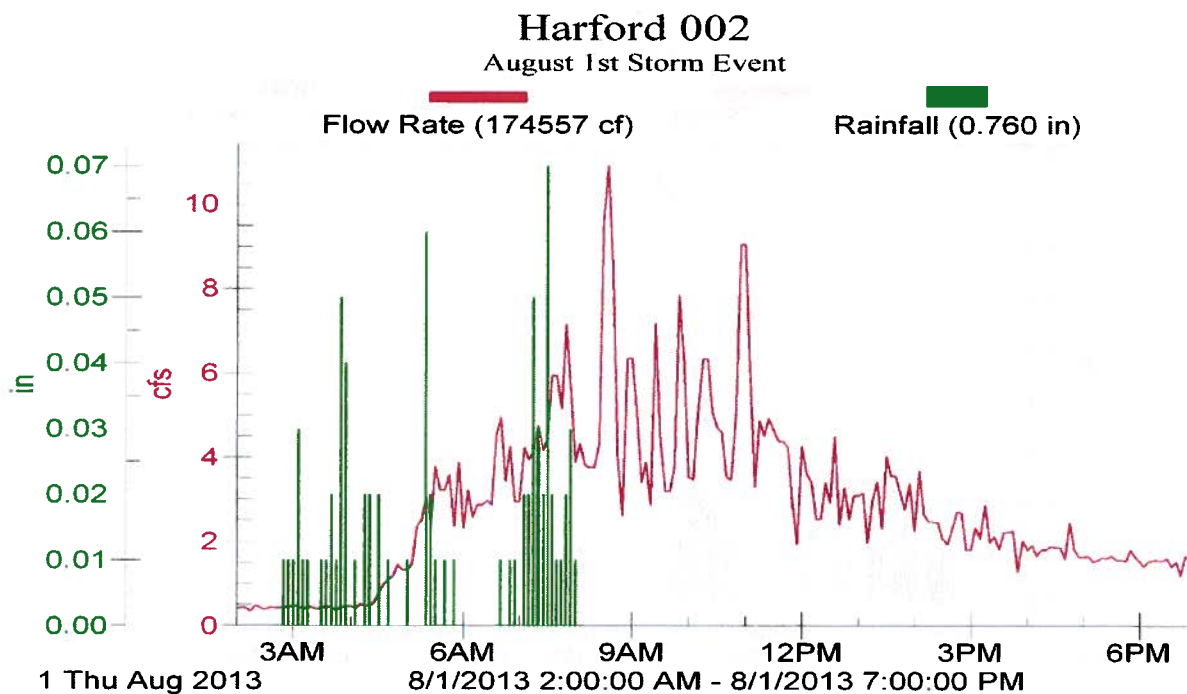


Figure 1. Hydrograph at Station WC002 for August 1, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

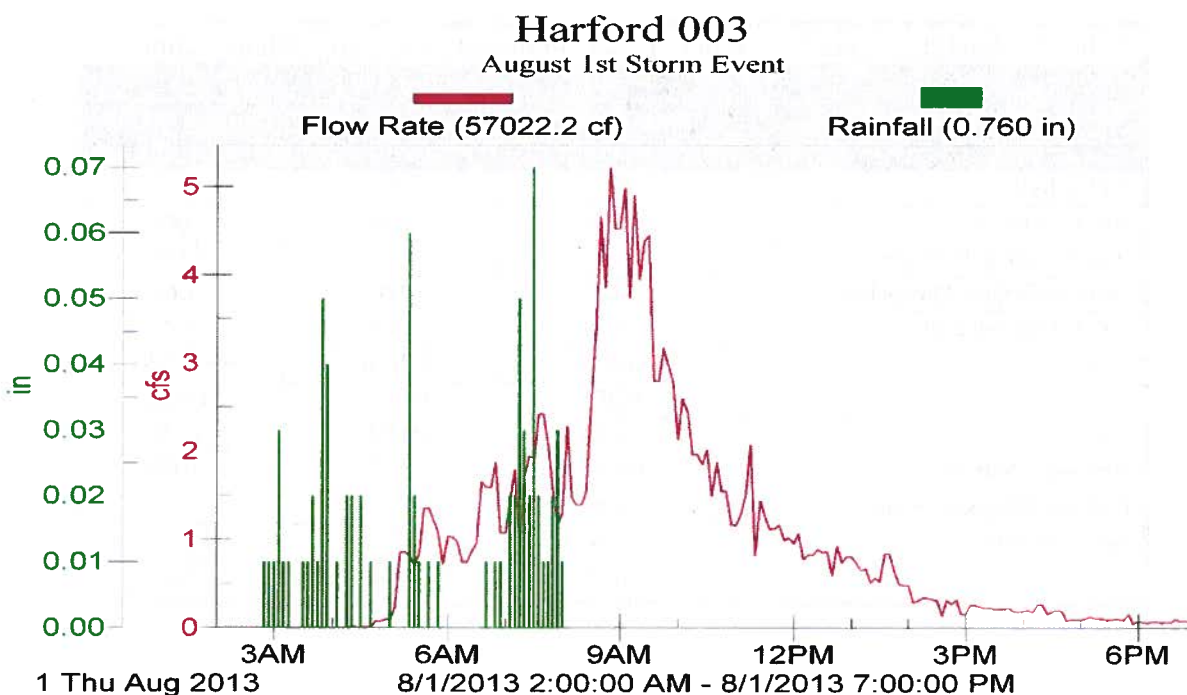


Figure 2. Hydrograph at Station WC003 for August 1, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.



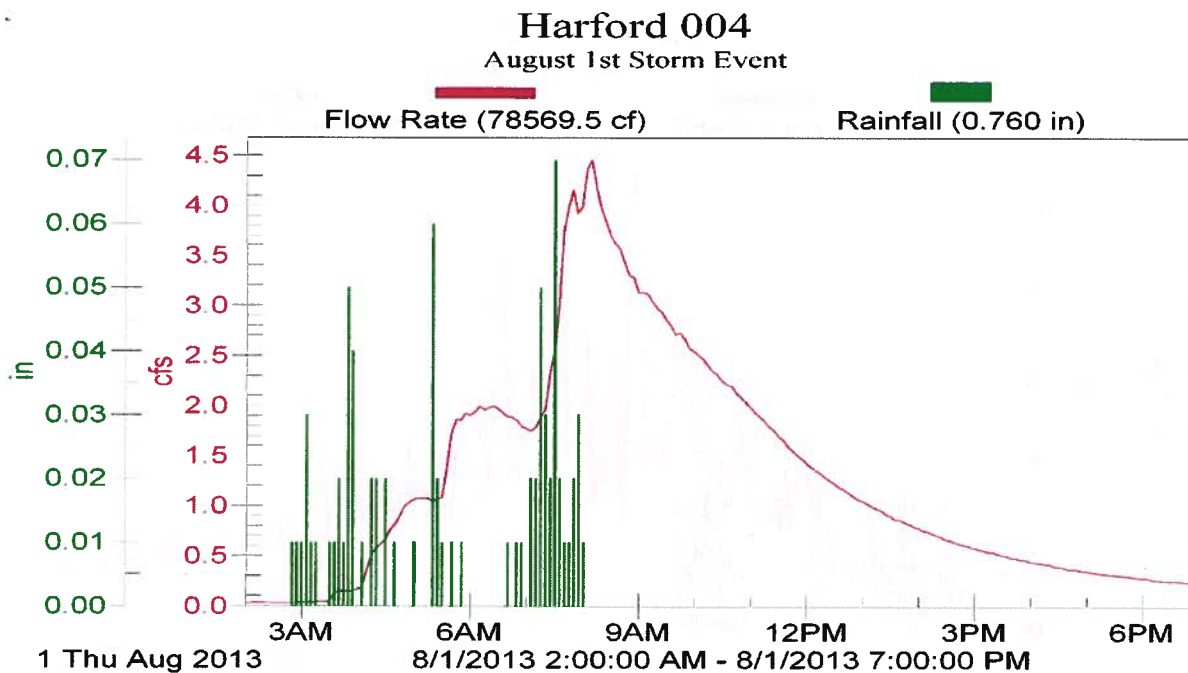


Figure 3. Hydrograph at Station WC004 for August 1, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	August 1, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	8	8	9
Nitrate Nitrogen	1.3	1.16	0.606
Nitrate-Nitrite Nitrogen	1.3	1.16	0.606
Orthophosphate Phosphorus	0.07	0.07	0.14
Solids (Suspended)	94.5	99.8	131
Copper	0.0088	0.0116	0.0198
Lead	0.0025	0.0041	0.0086
Zinc	0.0644	0.0938	0.129
Ammonia Nitrogen	0.0562	0.0626	< 0.099
Kjeldahl Nitrogen (Total)	2.63	1.3	1.41
Total Phosphorus	0.312	0.251	0.322
pH	6.61	7.04	7.08

Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb			
Constituent	August 1, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	8	7	3
Nitrate Nitrogen	0.905	0.626	0.457
Nitrate-Nitrite Nitrogen	0.905	0.626	0.457
Orthophosphate Phosphorus	0.07	0.07	0.05
Solids (Suspended)	107	93.3	24.5
Copper	0.0127	0.0122	0.0053
Lead	0.0048	0.0042	0.0012
Zinc	0.0855	0.0769	0.0334
Ammonia Nitrogen	< 0.099	0.0735	< 0.099
Kjeldahl Nitrogen (Total)	1.02	1.03	0.63
Total Phosphorus	0.209	0.217	0.0758
pH	7.14	7.21	7.11

Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb			
Constituent	August 1, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	3	4	< 2
Nitrate Nitrogen	0.749	0.62	0.521
Nitrate-Nitrite Nitrogen	0.749	0.62	0.521
Orthophosphate Phosphorus	0.03	0.04	0.04
Solids (Suspended)	7.5	14.3	9
Copper	0.0034	0.0037	0.0031
Lead	0.00062	0.00075	0.000484
Zinc	0.0236	0.0304	0.0325
Ammonia Nitrogen	< 0.099	0.111	0.0896
Kjeldahl Nitrogen (Total)	0.318	0.335	0.466
Total Phosphorus	0.0403	0.0551	0.0606
pH	7.09	7.05	6.87

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## **WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING**

### **SUMMARY REPORT**

*SEPTEMBER 21, 2013*

### **INTRODUCTION**

On September 21, 2013, Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

### **RESULTS**

Versar field staff traveled to the site on September 21 to program the Sigma automated samplers to sample the event. Rainfall initiated at approximately 4:10 p.m. on September 21. At the Wheel Creek Rain Gauge Station, 1.15 inches of rain was recorded.

On September 21, shortly after initial storm flow, field staff took grab water samples to be tested for TPH and *E. coli* at all three stations. Arrangements were made to meet with laboratory personnel at the Providence Road Park and Ride and the *E. coli* samples were handed over for analysis.

Field staff traveled to the station on September 23 to composite automated samples. Composite samples, including TPH, were transported to the County office building for pickup by the laboratory.

Hydrographs for the September 21 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the September 21 storm are shown in Table 1 through Table 4.



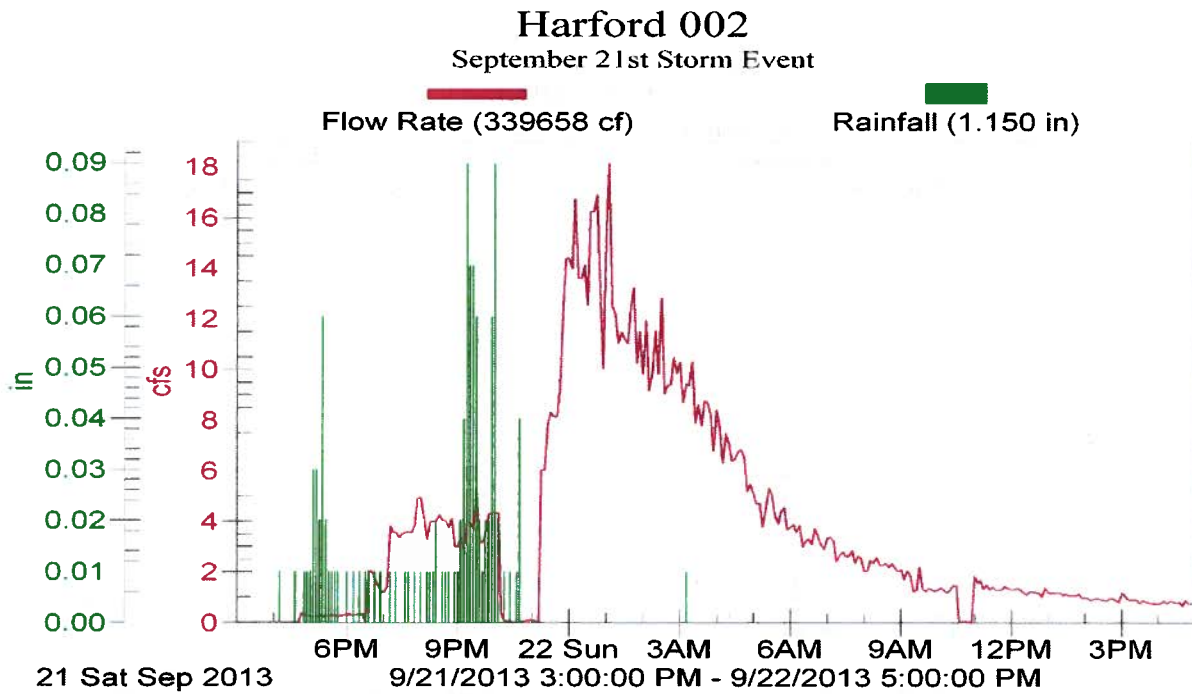


Figure 1. Hydrograph at Station WC002 for September 21, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

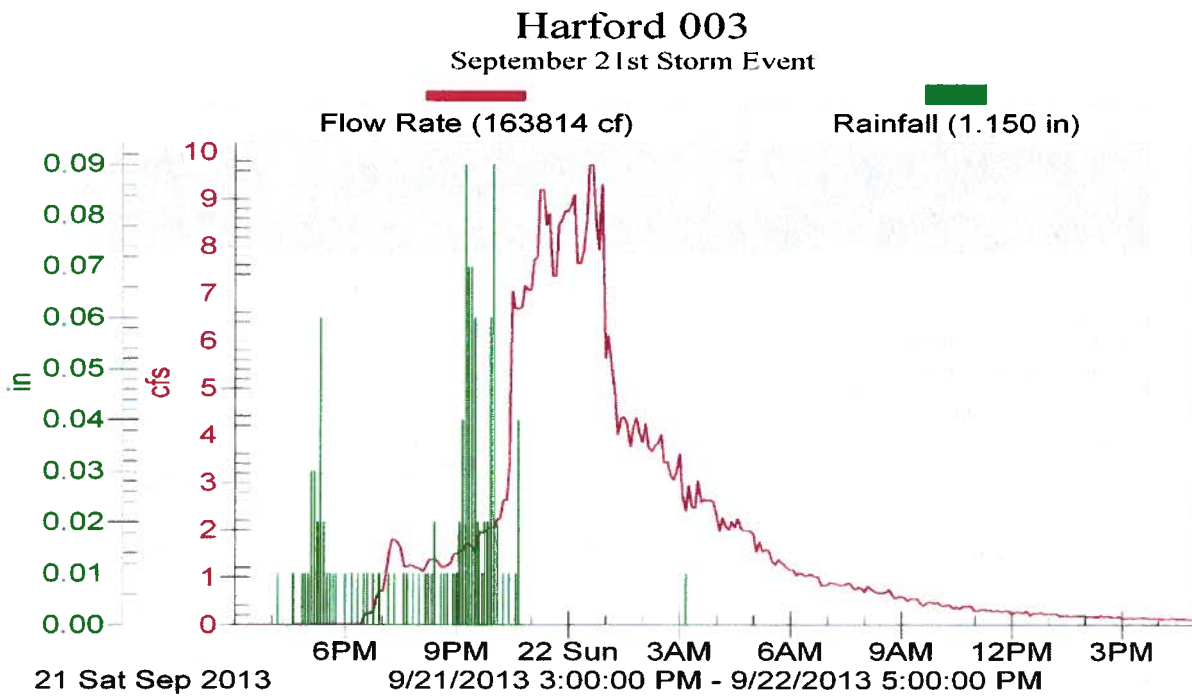


Figure 1. Hydrograph at Station WC003 for September 21, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

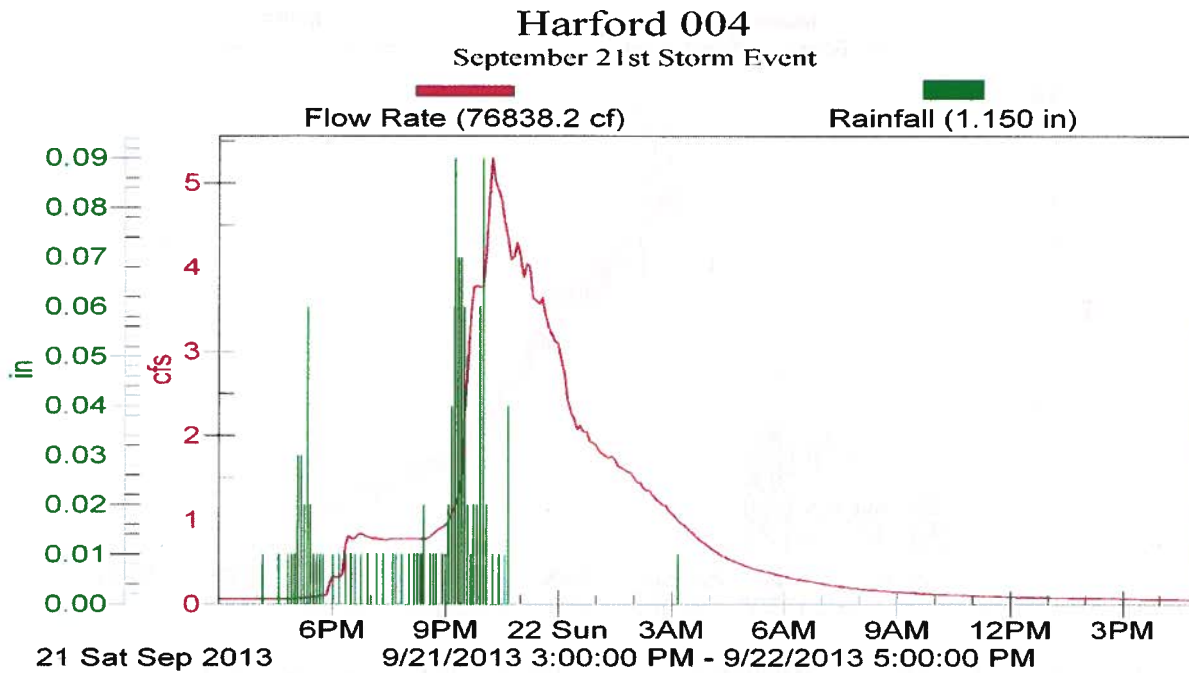


Figure 3. Hydrograph at Station WC004 for September 21, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	September 21, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	12	12	8
Nitrate Nitrogen	2.09	1.74	0.874
Nitrate-Nitrite Nitrogen	2.09	1.74	1.14
Orthophosphate Phosphorus	0.07	0.11	0.07
Solids (Suspended)	83.7	200	63
Copper	0.0059	0.0127	0.0112
Lead	0.0033	0.0079	0.0042
Zinc	0.063	0.136	0.0902
Ammonia Nitrogen	< 0.099	0.148	< 0.099
Kjeldahl Nitrogen (Total)	0.775	1.02	0.953
Total Phosphorus	0.191	0.368	0.211
pH	7.10	7.45	6.99

Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb			
Constituent	September 21, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	7	14	< 2
Nitrate Nitrogen	0.694	0.826	0.463
Nitrate-Nitrite Nitrogen	0.694	0.826	0.463
Orthophosphate Phosphorus	0.06	0.11	0.06
Solids (Suspended)	28	185	29.2
Copper	0.0047	0.0175	0.0046
Lead	0.0025	0.0082	0.0013
Zinc	0.0388	0.133	0.0374
Ammonia Nitrogen	< 0.099	< 0.099	0.178
Kjeldahl Nitrogen (Total)	0.693	1.69	0.667
Total Phosphorus	0.124	0.408	0.122
pH	7.53	7.84	7.16

Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb			
Constituent	September 21, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	< 2	8	5
Nitrate Nitrogen	1.52	0.719	0.544
Nitrate-Nitrite Nitrogen	1.52	0.719	0.544
Orthophosphate Phosphorus	0.02	0.07	0.05
Solids (Suspended)	< 5	14.6	18.6
Copper	0.001	0.0041	0.0032
Lead	0.0029	0.0033	0.00099
Zinc	0.0204	0.0334	0.04
Ammonia Nitrogen	< 0.099	0.113	< 0.099
Kjeldahl Nitrogen (Total)	0.224	0.529	0.401
Total Phosphorus	0.0202	0.109	0.0713
pH	7.10	7.67	7.13

Table 4. Analytical Results – Wheel Creek Grab Sampling			
Constituent	Station WC002	Station WC003	Station WC004
September 21, 2013 (rising)			
TPH (mg/L)	< 1.89	< 1.89	< 1.89
<i>E. coli</i> (MPN/100 ml)	> 2420	> 2420	1200
Temp (C)	18.9	20.6	18.5
DO (mg/L)	10.6	10.0	9.80
pH	7.34	7.36	7.05
Sp. Cond. (mS/cm <sup>2</sup> )	0.259	0.229	0.729



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## **WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING**

### **SUMMARY REPORT**

*NOVEMBER 18, 2013*

#### **INTRODUCTION**

On November 18, 2013, Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

#### **RESULTS**

Versar field staff traveled to the site on November 17 to pre-program the Sigma automated samplers to sample the event. Rainfall initiated at approximately 12:00 a.m. on November 18. At the Wheel Creek Rain Gauge Station, 0.14 inches of rain was recorded.

On November 18 during the falling limb, field staff took grab water samples to be tested for TPH and *E.coli* at all three stations. Arrangements were made to meet with laboratory personnel and *E.coli* samples were handed over for analysis.

Field staff traveled to the station on November 18 to composite automated samples. During compositing, field staff noted that the area velocity probe at WC002 malfunctioned during the event from unknown causes. Wedges used to composite samples at WC002 correspond to those used for WC004. Composite samples, including TPH, were transported to the County office building for pickup by the laboratory.

Hydrographs for the November 18 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the November 18 storm are shown in Table 1 through Table 4.

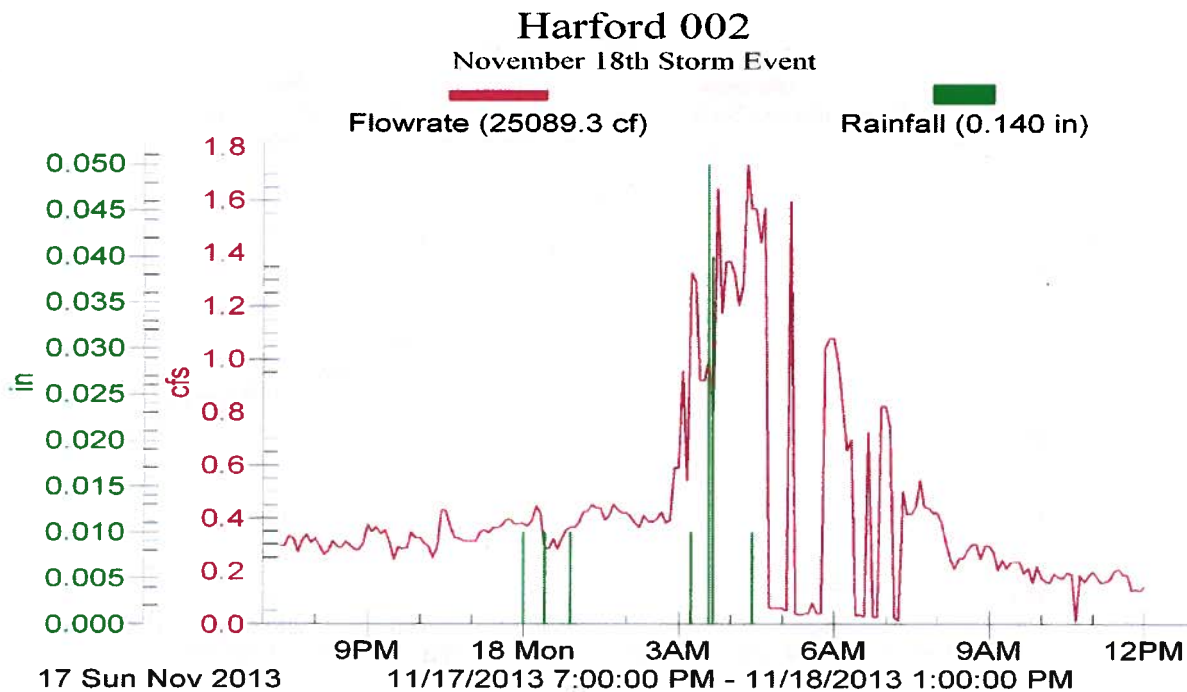


Figure 1. Hydrograph at Station WC002 for November 18, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

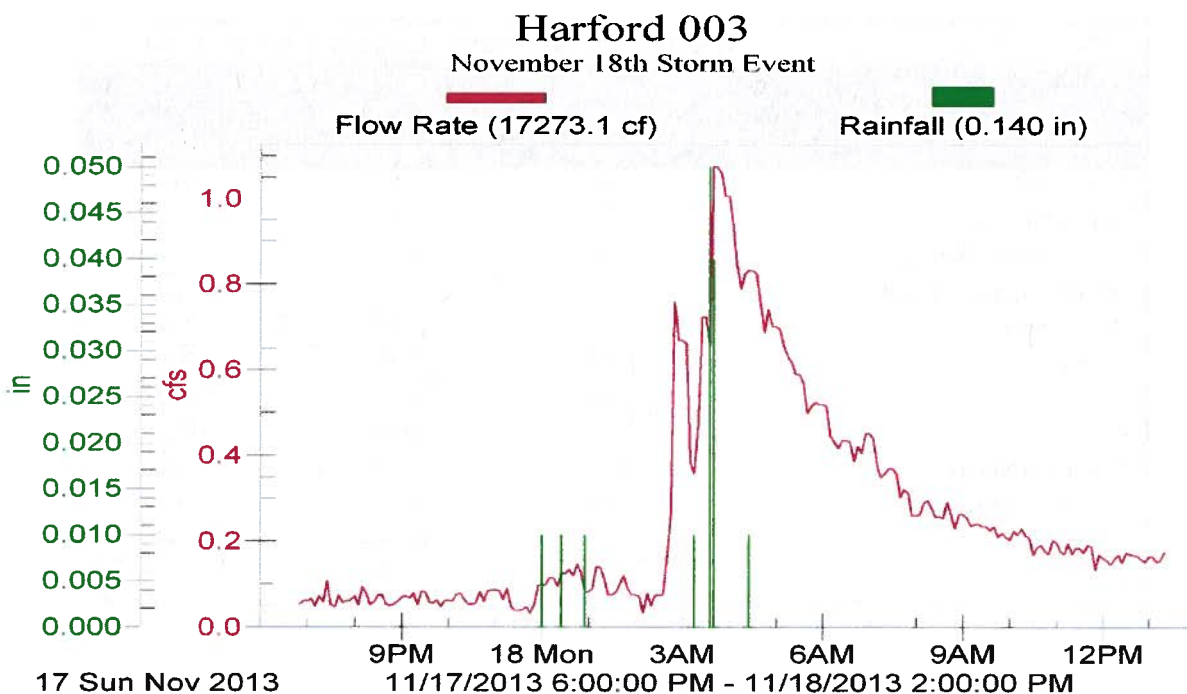


Figure 2. Hydrograph at Station WC003 for November 18, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

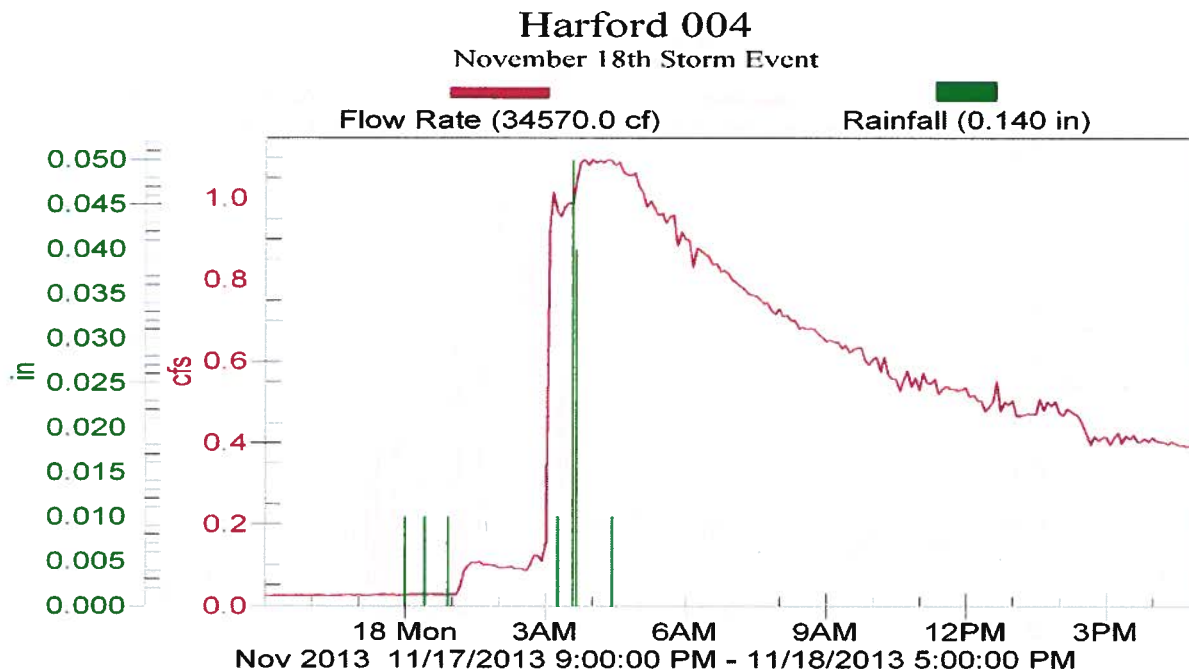


Figure 3. Hydrograph at Station WC004 for November 18, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	November 18, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	10	14	10
Nitrate Nitrogen	2.97	0.925	1.5
Nitrate-Nitrite Nitrogen	2.97	0.925	1.5
Orthophosphate Phosphorus	0.01	0.03	< 0.01
Solids (Suspended)	11.5	39.5	15
Copper	0.0035	0.0049	0.0062
Lead	0.00026	0.0012	0.0021
Zinc	0.0378	0.0592	0.0527
Ammonia Nitrogen	< 0.099	< 0.099	0.102
Kjeldahl Nitrogen (Total)	0.846	0.476	0.472
Total Phosphorus	< 0.01	0.0994	0.0448
pH	7.24	7.36	7.37



**Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb**

Constituent	November 18, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	10	10	< 2
Nitrate Nitrogen	0.994	1.29	0.793
Nitrate-Nitrite Nitrogen	0.994	1.29	0.793
Orthophosphate Phosphorus	0.01	0.01	0.02
Solids (Suspended)	11.8	9	4.6
Copper	0.0029	0.0021	0.004
Lead	0.00032	0.0013	0.00064
Zinc	0.0349	0.0459	0.0332
Ammonia Nitrogen	< 0.099	< 0.099	< 0.099
Kjeldahl Nitrogen (Total)	0.394	0.292	0.295
Total Phosphorus	0.0295	0.0255	0.0332
pH	7.34	7.30	7.58

**Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb**

Constituent	November 18, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	< 2	7	< 2
Nitrate Nitrogen	0.779	0.727	0.837
Nitrate-Nitrite Nitrogen	0.779	0.727	0.837
Orthophosphate Phosphorus	< 0.01	< 0.01	0.02
Solids (Suspended)	< 5	< 5	< 5
Copper	0.0063	0.0024	0.0045
Lead	0.0014	0.00018	0.00038
Zinc	0.0445	0.0294	0.0384
Ammonia Nitrogen	< 0.099	< 0.099	< 0.099
Kjeldahl Nitrogen (Total)	0.384	0.218	0.246
Total Phosphorus	< 0.05	< 0.01	0.0222
pH	7.43	7.43	7.35

**Table 4. Analytical Results – Wheel Creek Grab Sampling**

Constituent	Station WC002	Station WC003	Station WC004
November 18, 2013 (falling)			
TPH (mg/L)	< 1.89	< 1.89	< 1.89
<i>E. coli</i> (MPN/100 ml)	727	> 2420	> 2420
Temp (C)	12.0	11.9	12.7
DO (mg/L)	8.55	8.49	7.43
pH	7.70	7.46	7.29
Sp. Cond. (mS/cm <sup>2</sup> )	0.261	0.270	0.186

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## **WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING SUMMARY REPORT**

*NOVEMBER 26, 2013*

### **INTRODUCTION**

On November 26, 2013, Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

### **RESULTS**

Versar field staff traveled to the site on November 26 to program the Sigma automated samplers to sample the event. Rainfall initiated at approximately 10:15 a.m. on November 26. At the Wheel Creek Rain Gauge Station, 1.80 inches of rain were recorded.

On November 26 shortly after initial storm flow, field staff took grab water samples to be tested for TPH and *E. coli* at all three stations. Arrangements were made to meet with laboratory personnel and *E. coli* samples were handed over for analysis.

Field staff traveled to the station on November 27 to composite automated samples. Field staff noted that both WC002 and WC003 area velocity probes malfunctioned during the event. Erroneous data are most likely caused by high flow. Wedges used to composite both stations correspond to wedges used at WC004. Composite samples, including TPH, were transported to the County office building for pickup by the laboratory.

Hydrographs for the November 26 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the November 26 storm are shown in Table 1 through Table 4. Note that analytical results for BOD, nitrate, and orthophosphate are unavailable. Due to laboratory Thanksgiving holiday hours, hold times expired before the samples could be processed.

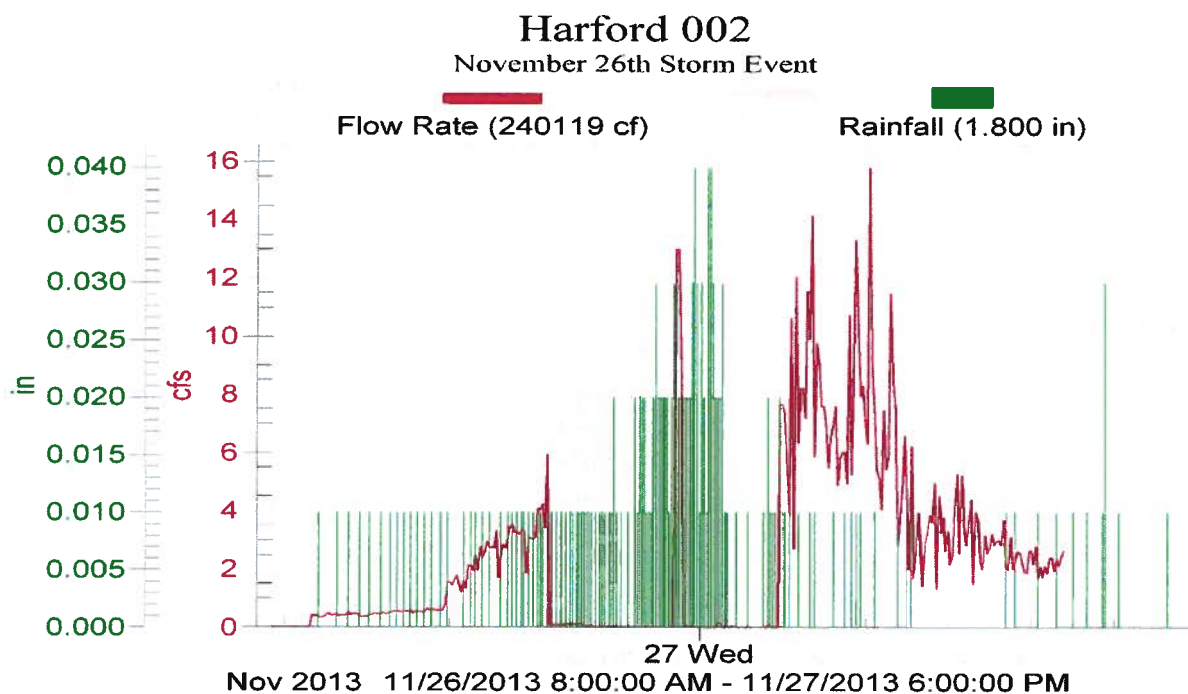


Figure 1. Hydrograph at Station WC002 for November 26, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

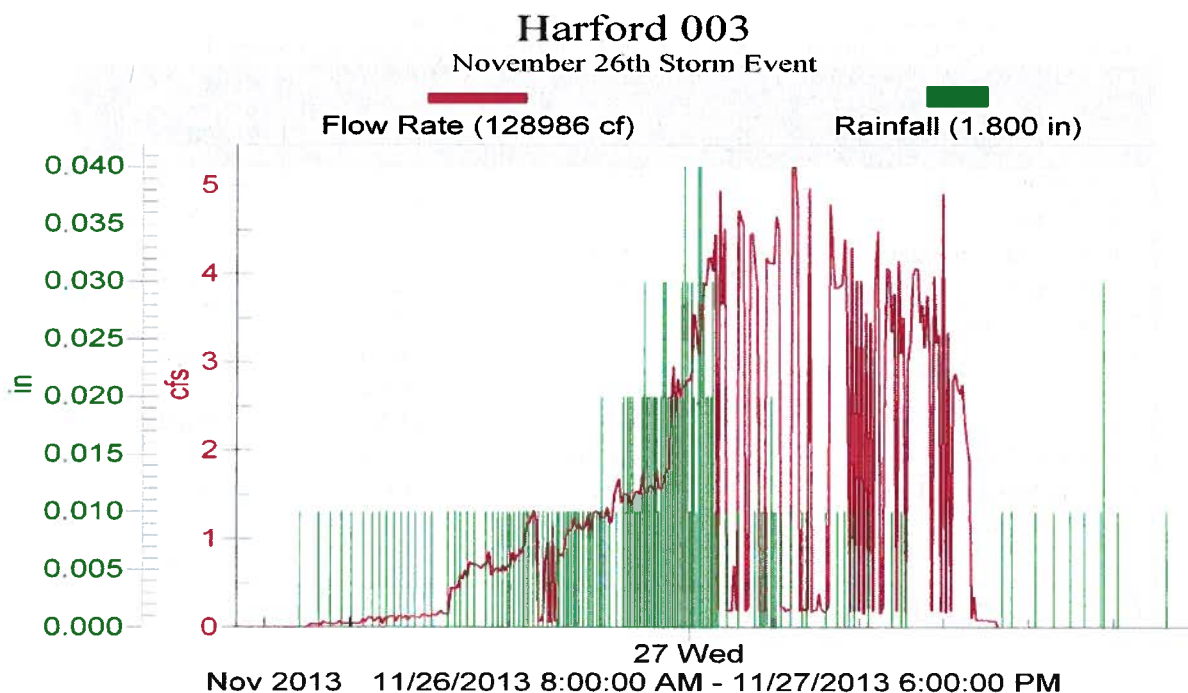


Figure 2. Hydrograph at Station WC003 for November 26, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.



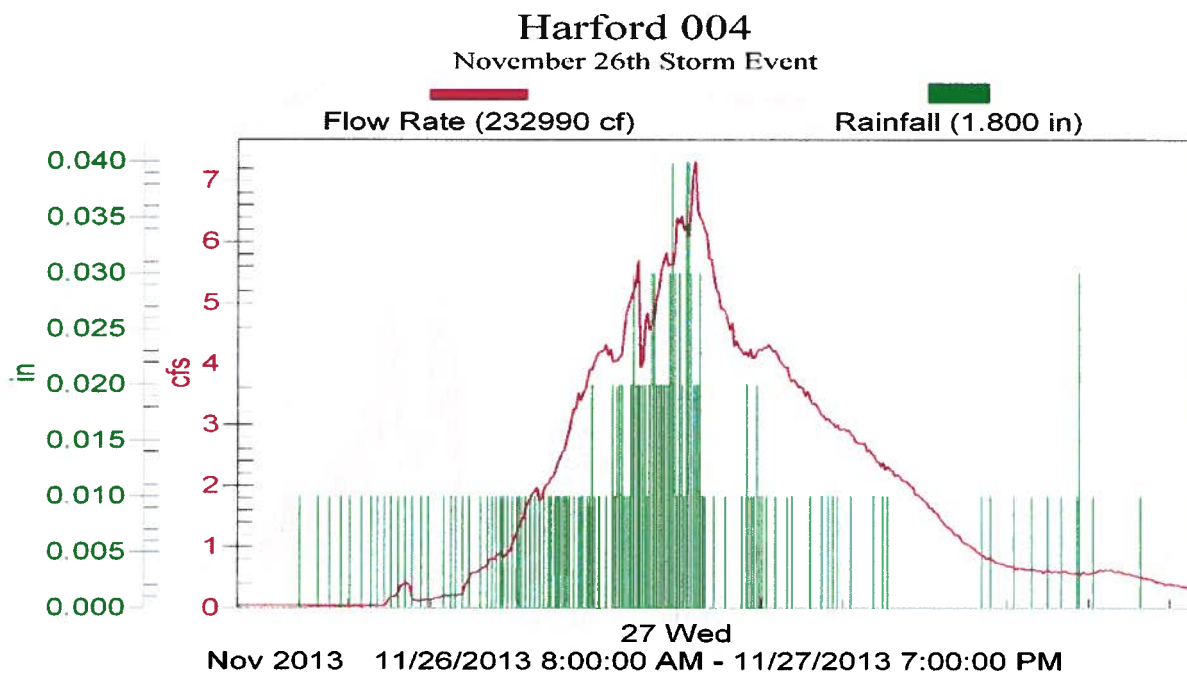


Figure 3. Hydrograph at Station WC004 for November 26, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	November 26, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	N.T.	N.T.	N.T.
Nitrate Nitrogen	N.T.	N.T.	N.T.
Nitrate-Nitrite Nitrogen	1.98	1.84	0.798
Orthophosphate Phosphorus	N.T.	N.T.	N.T.
Solids (Suspended)	9.6	25.6	22.4
Copper	0.003	0.0035	0.0068
Lead	0.00083	0.00082	0.0026
Zinc	0.0334	0.0524	0.0468
Ammonia Nitrogen	< 0.099	< 0.099	0.13
Kjeldahl Nitrogen (Total)	0.347	0.492	0.854
Total Phosphorus	0.029	0.065	0.123
pH	7.53	7.43	7.19
N.T. = Analyte Not Tested			

Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb			
Constituent	November 26, 2013		
	Station WC002 (mg/L.)	Station WC003 (mg/L.)	Station WC004 (mg/L.)
5-Day BOD	N.T.	N.T.	N.T.
Nitrate Nitrogen	N.T.	N.T.	N.T.
Nitrate-Nitrite Nitrogen	0.662	0.828	1.2
Orthophosphate Phosphorus	N.T.	N.T.	N.T.
Solids (Suspended)	79.8	31.4	14.8
Copper	0.008	0.0061	0.0037
Lead	0.0022	0.0021	0.0011
Zinc	0.0635	0.0488	0.0349
Ammonia Nitrogen	< 0.099	< 0.099	< 0.099
Kjeldahl Nitrogen (Total)	1.16	0.801	0.521
Total Phosphorus	0.202	0.148	0.079
pH	7.77	7.68	7.29
N.T. = Analyte Not Tested			

Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb			
Constituent	November 26, 2013		
	Station WC002 (mg/L.)	Station WC003 (mg/L.)	Station WC004 (mg/L.)
5-Day BOD	N.T.	N.T.	N.T.
Nitrate Nitrogen	N.T.	N.T.	N.T.
Nitrate-Nitrite Nitrogen	0.761	0.925	0.642
Orthophosphate Phosphorus	N.T.	N.T.	N.T.
Solids (Suspended)	17.4	16	< 5
Copper	0.0047	0.005	0.0025
Lead	0.00095	0.0013	0.00071
Zinc	0.0415	0.0381	0.0317
Ammonia Nitrogen	< 0.099	< 0.099	< 0.099
Kjeldahl Nitrogen (Total)	0.498	0.611	0.263
Total Phosphorus	0.088	0.103	0.026
pH	7.28	7.47	7.20
N.T. = Analyte Not Tested			

Table 4. Analytical Results – Wheel Creek Grab Sampling			
Constituent	Station WC002	Station WC003	Station WC004
November 26, 2013 (rising)			
TPH (mg/L)	< 1.89	< 1.89	< 1.89
<i>E. coli</i> (MPN/100 ml)	29.2	1300	54.6
Temp (C)	5.08	4.89	6.88
DO (mg/L)	10.28	10.50	7.78
pH	7.43	7.17	7.41
Sp. Cond. (mS/cm <sup>2</sup> )	0.440	0.525	0.799

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## **WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING SUMMARY REPORT**

*DECEMBER 6, 2013*

### **INTRODUCTION**

On December 6, 2013, Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

### **RESULTS**

Versar field staff traveled to the site on December 5 to program the Sigma automated samplers to sample the event. Rainfall initiated approximately 11:30 a.m. on December 6. At the Wheel Creek Rain Gauge Station, 0.75 inches of rain was recorded.

On December 6, shortly after initial storm flow, field staff took grab water samples to be tested for TPH and E. coli at all three stations. Arrangements were made to meet with laboratory personnel and E. coli samples were handed over for analysis.

Field staff traveled to the station on December 8 to composite automated samples. Composite samples, including TPH, were transported to the County office building for pickup by the laboratory.

Hydrographs for the December 6 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the December 6 storm are shown in Table 1 through Table 4.



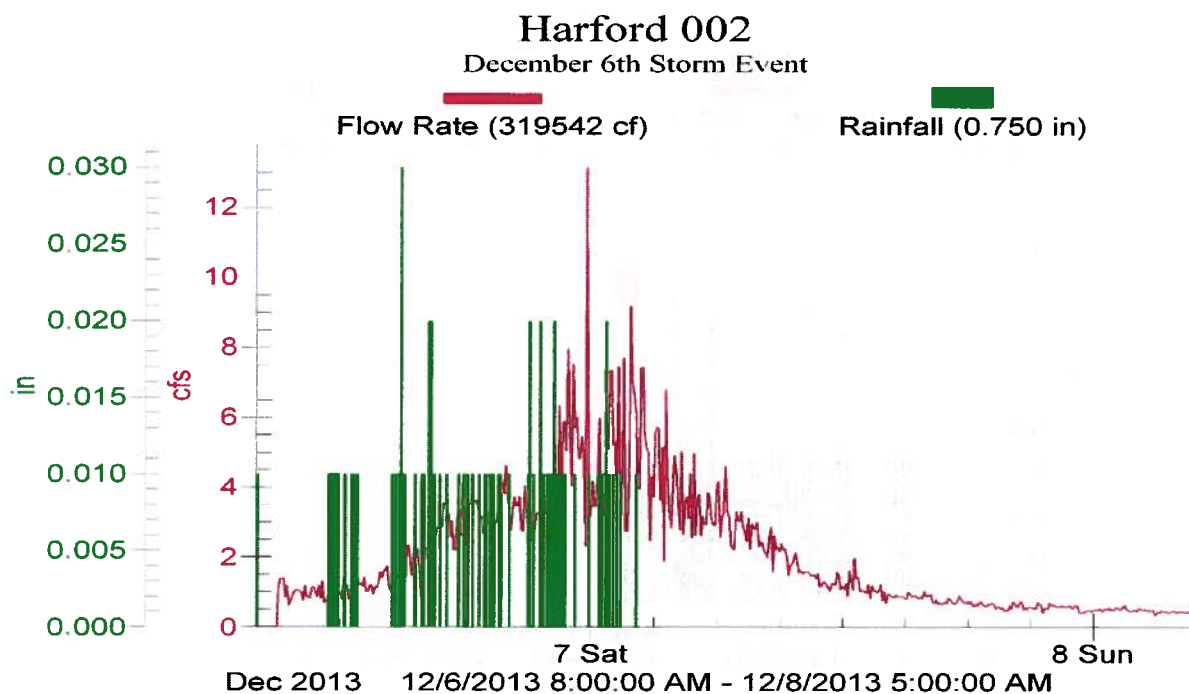


Figure 1. Hydrograph at Station WC002 for December 6, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

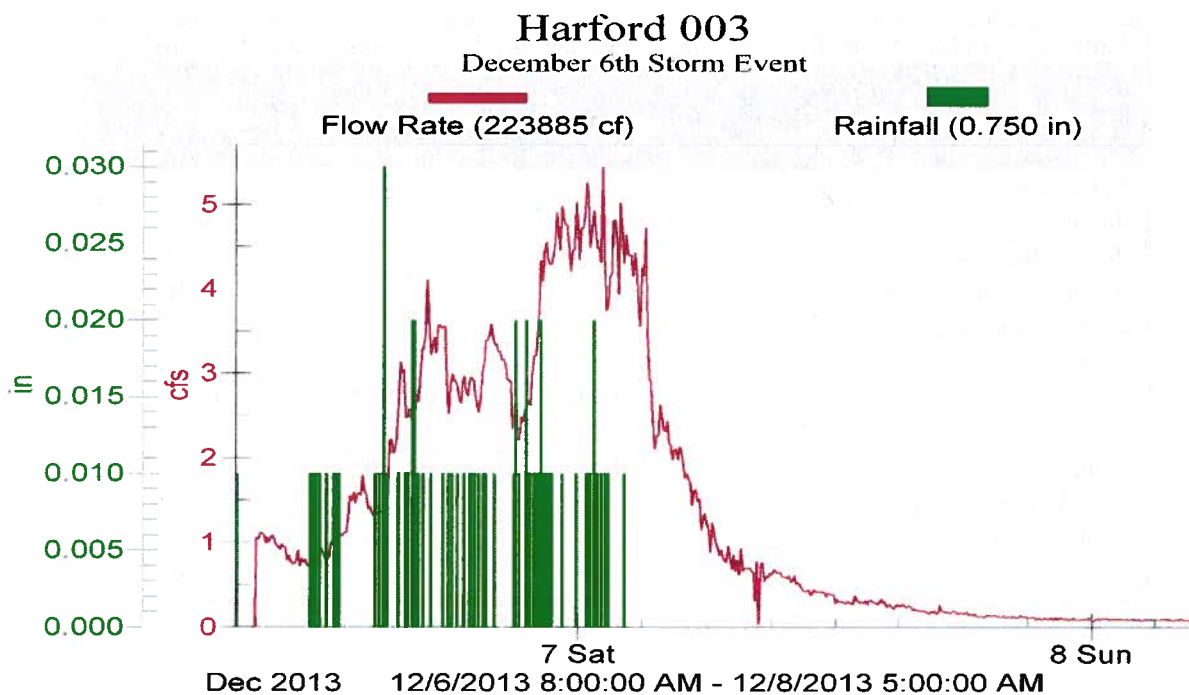


Figure 2. Hydrograph at Station WC003 for December 6, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

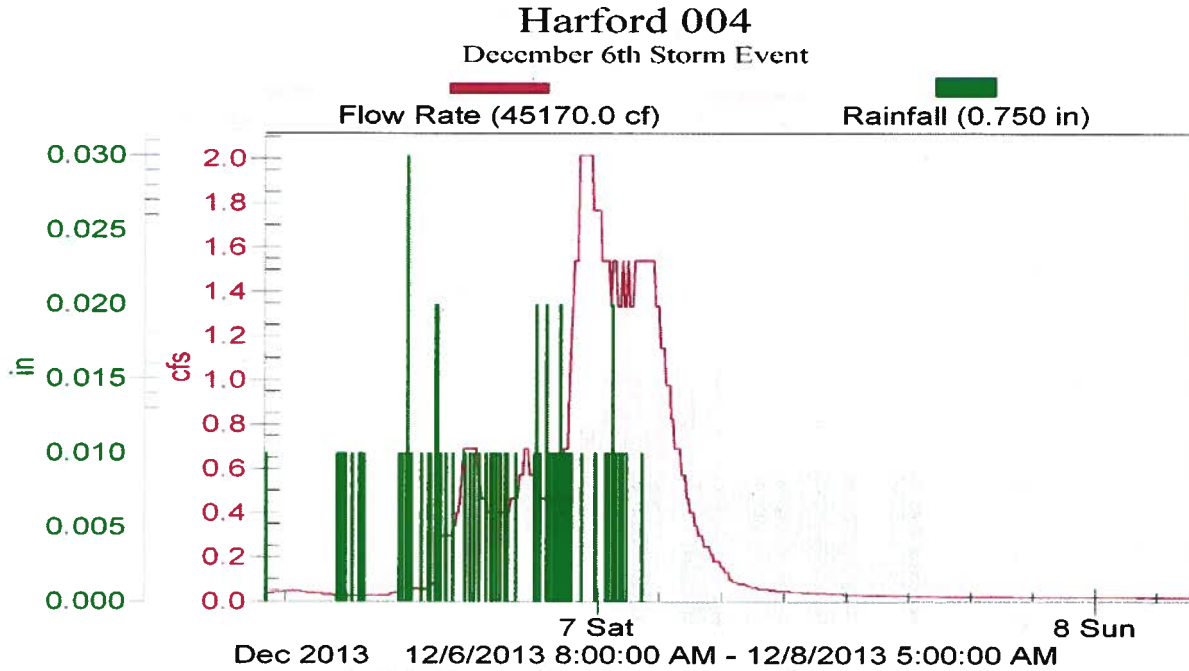


Figure 3. Hydrograph at Station WC004 for December 6, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	December 6, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	5	14	21
Nitrate Nitrogen	0.968	0.674	0.635
Nitrate-Nitrite Nitrogen	0.968	0.674	0.635
Orthophosphate Phosphorus	< 0.01	< 0.01	0.01
Solids (Suspended)	< 5	9	177
Copper	0.0037	0.0047	0.0228
Lead	0.00041	0.00065	0.0076
Zinc	0.0336	0.0405	0.116
Ammonia Nitrogen	< 0.099	< 0.099	0.109
Kjeldahl Nitrogen (Total)	0.248	0.372	1.19
Total Phosphorus	0.0145	0.042	0.286
pH	6.95	6.81	7.08

Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb			
Constituent	December 6, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	< 2	< 2	< 2
Nitrate Nitrogen	0.579	0.594	0.402
Nitrate-Nitrite Nitrogen	0.579	0.594	0.402
Orthophosphate Phosphorus	0.03	0.02	0.02
Solids (Suspended)	6.5	< 5	10.8
Copper	0.0068	0.005	0.0054
Lead	0.00068	0.00063	0.00094
Zinc	0.0333	0.0332	0.0389
Ammonia Nitrogen	0.112	0.172	0.152
Kjeldahl Nitrogen (Total)	0.372	0.347	0.304
Total Phosphorus	< 0.01	0.0454	0.049
pH	7.09	6.95	7.14

Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb			
Constituent	December 6, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	< 2	< 2	< 2
Nitrate Nitrogen	0.602	0.502	0.366
Nitrate-Nitrite Nitrogen	0.602	0.502	0.366
Orthophosphate Phosphorus	0.02	0.02	0.02
Solids (Suspended)	< 5	< 5	5.5
Copper	0.0045	0.0046	0.0056
Lead	0.00058	0.00053	0.00065
Zinc	0.0308	0.0327	0.0415
Ammonia Nitrogen	0.114	0.103	0.134
Kjeldahl Nitrogen (Total)	0.453	0.408	0.204
Total Phosphorus	0.0688	0.0475	0.0313
pH	7.04	7.17	7.07

Table 4. Analytical Results – Wheel Creek Grab Sampling			
Constituent	Station WC002	Station WC003	Station WC004
December 6, 2013 (rising)			
TPH (mg/L)	< 1.89	< 1.89	< 1.89
<i>E. coli</i> (MPN/100 ml)	1050	1550	2420
Temp (C)	11.18	10.98	12.41
DO (mg/L)	10.02	9.51	9.28
pH	6.71	6.64	6.65
Sp. Cond. (mS/cm <sup>2</sup> )	0.298	0.322	0.144



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## **WHEEL CREEK RESTORATION AND RETROFIT STORM MONITORING**

### **SUMMARY REPORT**

*DECEMBER 13, 2013 STORM*

#### **INTRODUCTION**

On December 13, 2013, Versar conducted storm monitoring at the Wheel Creek stations. Samples were successfully collected at Station WC002, WC003, and WC004 using the Sigma 900Max automated samplers. This report presents water chemistry results for this event.

Site locations are as follows:

- Station WC004: Located on north side of Wheel Court, downstream of DNR's stream monitoring station. Flow sensor is located on stream bottom.
- Station WC003: Located on south side of Cinnabar Lane, west of Wheel Road. Flow sensor is located within outfall pipe.
- Station WC002: Located on south side of Wheel Road, just west of junction of Arthurs Woods Drive. Flow sensor is located within culvert.

#### **RESULTS**

Versar field staff traveled to the site on December 12 to pre-program the Sigma automated samplers to sample the event. Rainfall initiated at approximately 11:45 a.m. on December 13. At the Wheel Creek Rain Gauge Station, 0.79 inches of rain were recorded.

Field staff traveled to the station on December 16 to composite automated samples. Composite samples were transported to the County office building for pickup by the laboratory. Rainfall was predicted to initiate during the hours of 12:00 a.m. and 6:00 a.m. Samplers were pre-programmed, therefore, no grab sample data are available.

Hydrographs for the December 13 storm are presented in Figure 1 through Figure 3 below. Laboratory analytical and field water quality results for the December 13 storm are shown in Table 1 through Table 3.

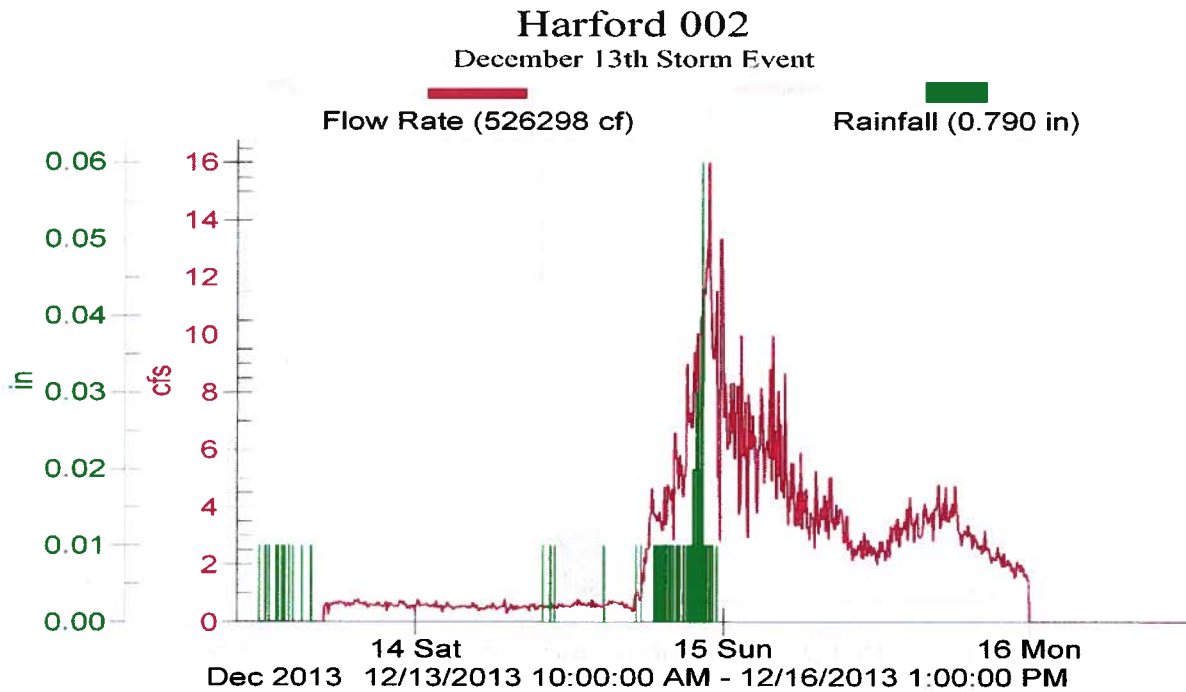


Figure 1. Hydrograph at Station WC002 for December 13, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

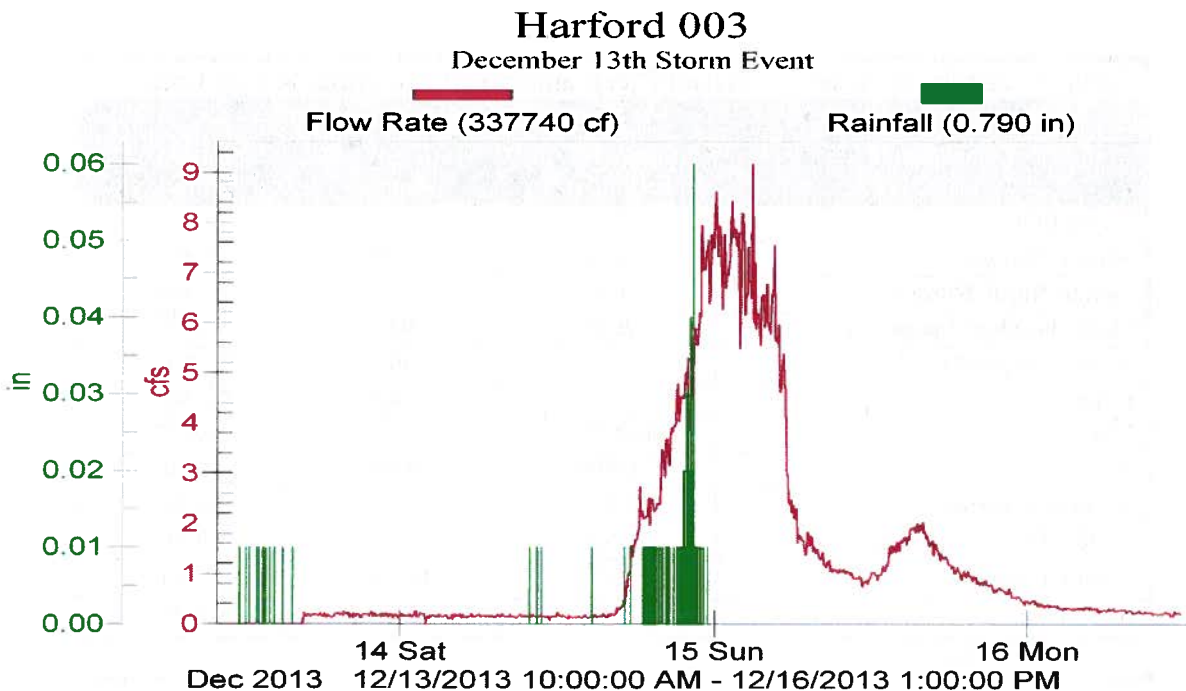


Figure 2. Hydrograph at Station WC003 for December 13, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

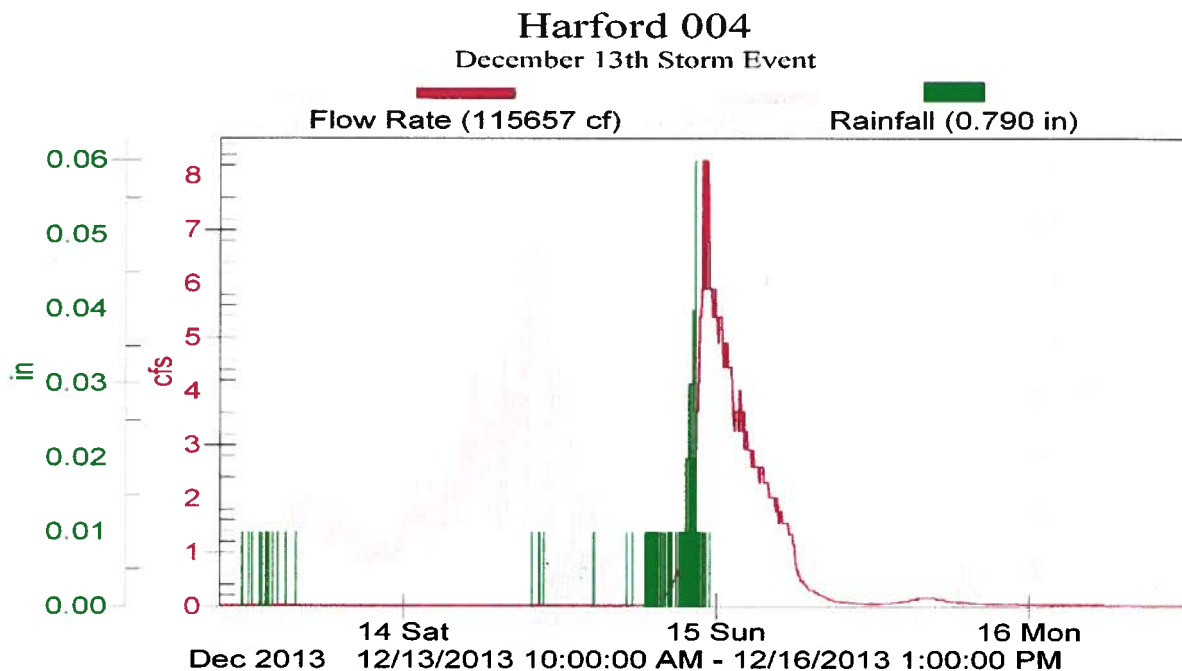


Figure 3. Hydrograph at Station WC004 for December 13, 2013 storm. Rainfall data source: Wheel Creek Rain Gauge Station.

Table 1. Analytical results – Wheel Creek automated sampling, Rising Limb			
Constituent	December 13, 2013		
	Station WC002 (mg/L)	Station WC003 (mg/L)	Station WC004 (mg/L)
5-Day BOD	< 2	5	5
Nitrate Nitrogen	1.74	1.37	0.676
Nitrate-Nitrite Nitrogen	1.74	1.37	0.676
Orthophosphate Phosphorus	0.02	0.02	0.03
Solids (Suspended)	14.5	39.3	29
Copper	0.0031	0.0059	0.0095
Lead	0.00075	0.0017	0.0025
Zinc	0.0584	0.104	0.102
Ammonia Nitrogen	0.207	0.213	0.202
Kjeldahl Nitrogen (Total)	0.569	0.8	0.815
Total Phosphorus	0.0359	0.0841	0.103
pH	N.C.	N.C.	N.C.
N.C. = Not Collected			



Table 2. Analytical results – Wheel Creek automated sampling, Peak Limb			
Constituent	December 13, 2013		
	Station WC002 (mg/L.)	Station WC003 (mg/L.)	Station WC004 (mg/L.)
5-Day BOD	7	5	4
Nitrate Nitrogen	0.548	0.622	0.496
Nitrate-Nitrite Nitrogen	0.548	0.622	0.496
Orthophosphate Phosphorus	0.05	0.03	0.04
Solids (Suspended)	73	44.3	37.6
Copper	0.008	0.0071	0.0067
Lead	0.0028	0.002	0.0019
Zinc	0.0593	0.0605	0.0567
Ammonia Nitrogen	0.1	< 0.099	< 0.099
Kjeldahl Nitrogen (Total)	0.997	0.778	0.503
Total Phosphorus	0.157	0.146	0.0991
pH	N.C.	N.C.	N.C.
N.C. = Not Collected			

Table 3. Analytical results – Wheel Creek automated sampling, Falling Limb			
Constituent	December 13, 2013		
	Station WC002 (mg/L.)	Station WC003 (mg/L.)	Station WC004 (mg/L.)
5-Day BOD	5	< 2	< 2
Nitrate Nitrogen	0.687	0.603	0.434
Nitrate-Nitrite Nitrogen	0.687	0.603	0.434
Orthophosphate Phosphorus	0.03	0.03	0.02
Solids (Suspended)	16.5	< 5	16
Copper	0.004	0.0036	0.0031
Lead	0.00092	0.00066	0.0013
Zinc	0.044	0.042	0.0577
Ammonia Nitrogen	< 0.099	< 0.099	< 0.099
Kjeldahl Nitrogen (Total)	0.514	0.368	0.503
Total Phosphorus	0.0745	0.0421	0.0991
pH	N.C.	N.C.	N.C.
N.C. = Not Collected			

## **APPENDIX B**

### **RATING CURVE**

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Table B-1. Station WC004 2013 rating curve from data points

Level (ft)	Flow Rate (cfs)
1.27	5.170
1.24	4.413
1.22	3.966
1.17	3.432
1.12	2.542
1.09	2.215
1.04	1.750
0.93	1.000
0.83	0.450
0.75	0.046

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## **APPENDIX C**

### **RAINFALL TOTALS**



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Table C-1. 2013 Rainfall Data (Inches) from Onset Hoboware gauge at Station WC002

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0	0	N.A.	N.A.	N.A.	0	0.08	1.8	0	0	0.3	0
2	0	0	N.A.	N.A.	N.A.	0.16	0	0.01	0	0	0	0
3	0	0.05	N.A.	N.A.	N.A.	1.08	0.05	0.02	0	0	0	0
4	0	0	N.A.	N.A.	N.A.	0	0	0	0	0	0	0
5	0	0	N.A.	N.A.	N.A.	0.01	0	0	0	0	0	0
6	0	0.01	N.A.	N.A.	N.A.	0.22	0	0.5	0	0	0	0.81
7	0	0	N.A.	N.A.	N.A.	2.2	0	0.14	0	0.58	0.07	0.11
8	0	0.21	N.A.	N.A.	0	0	0	0.22	0	0	0	0
9	0	0	N.A.	N.A.	0.02	0	0.01	0.04	0	0.03	0	0.5
10	0	0	N.A.	N.A.	0.72	1.68	0.02	0	0	1.46	0	0.03
11	0.24	0.34	N.A.	N.A.	0.39	0	0.08	0	0	1.24	0	0.04
12	0	0	N.A.	N.A.	0	0	1.35	0	0.1	0.15	0	0
13	0.01	0.16	N.A.	N.A.	0	0.63	0.02	0.32	0.01	0.03	0	0.11
14	0.19	0.16	N.A.	N.A.	0.02	0.05	0	0	0	0	0	0.68
15	0.43	0.09	N.A.	N.A.	0.08	0	0	0	0	0	0	0
16	0.67	0.01	N.A.	N.A.	0	0.01	0	0	0.02	0	0.06	0
17	0	0	N.A.	N.A.	0	0	0	0	0	0.01	0.01	0
18	0	0	N.A.	N.A.	0.03	0.1	0	0.03	0	0	0.13	0
19	0	0.13	N.A.	N.A.	0.08	0.01	0.25	0	0	0.09	0	0
20	0	0	N.A.	N.A.	0	0	0	0	0	0	0	0
21	0	0	N.A.	N.A.	0	0	0.02	0	1.14	0	0	0.02
22	0	0.01	N.A.	N.A.	0	0	0.36	0	0.01	0	0	0.85
23	0	0.12	N.A.	N.A.	0.74	0	0.04	0	0	0	0	0
24	0	0	N.A.	N.A.	0.07	0	0	0	0	0	0	0
25	0	0	N.A.	N.A.	0	0.07	0	0	0	0	0	0
26	0	0.65	N.A.	N.A.	0	0.02	0	0	0	0	1.15	0
27	0.03	0.08	N.A.	N.A.	0	0.31	0	0	0	0	0.65	0
28	0.08	N.A.	N.A.	N.A.	0.13	0.04	0.02	0.49	0	0	0	0.83
29	0		N.A.	N.A.	0	0	0	0	0	0	0	0
30	0.99		N.A.	N.A.	0	0	0	0	0	0.13	0	0
31	0.49		N.A.		0		0	0		0.01		0
<b>Total Rain</b>	<b>3.13</b>	<b>2.02*</b>	<b>N.A.</b>	<b>N.A.</b>	<b>2.28*</b>	<b>6.59</b>	<b>2.30</b>	<b>3.57</b>	<b>1.28</b>	<b>3.73</b>	<b>2.37</b>	<b>3.98</b>

N.A. = data not available

\* = suspect/incomplete data

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